TABLE OF CONTENTS

GENERAL INFORMATION AND GUIDELINES

FORMS

CERTIFICATIONS (to be used during negotiation, if selected for award)

DOE MODEL AGREEMENT FOR PROPERTY AND COMMERCIALIZATION RIGHTS

DEPARTMENT OF ENERGY SOLICITATIONS FOR THE SMALL BUSINESS INNOVATION RESEARCH AND SMALL BUSINESS TECHNOLOGY TRANSFER PROGRAMS

GENERAL INFORMATION AND GUIDELINES

1. DESCRIPTION OF PROGRAMS

1.1 INTRODUCTION

This document describes two solicitations under which small businesses are invited to submit grant applications to two separate Department of Energy (DOE) programs: the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. These annual solicitations, the twentieth for SBIR and the ninth for STTR, are issued pursuant to the Small Business Innovation Research Program Reauthorization Act of 2000 (Public Law 106-554) and the Small Business Research and Development Act of 1992 (Public Law 102-564). Small businesses with strong research capabilities in science or engineering in any of the topic areas described in the Technical Topics section of this document are encouraged to participate.

The solicitations are presented in a single document because the two programs are very similar. *The major difference is that STTR grants* ***must*** *involve substantial cooperative research collaboration between the small business and a non-profit research institution (defined in Section 2.8).* However, it should be noted that the SBIR program also permits substantial collaboration between the small business and other organizations, including non-profit research institutions. The difference is that in SBIR, the collaboration is optional, and *in STTR, the collaboration is required and must be cooperative in nature*. **In the rest of this document, *italics* will be used to identify information that pertains *exclusively* to the *STTR* program.**

The objectives of these programs include increasing private sector commercialization of technology developed through DOE-supported R&D, stimulating technological innovation in the private sector, and improving the return on investment from federally funded research for economic and social benefits to the nation. DOE will support high-quality research or research and development (R&D) on advanced concepts concerning important mission-related scientific or engineering problems and opportunities that could lead to significant public benefit if the research is successful.

1.2 THREE-PHASE PROGRAMS

These solicitations are for Phase I grant applications only, but this document describes some aspects of Phase II grants as reference information.

Phase I: Phase I grant awards from these competitions will be made during fiscal year 2002 to small businesses, in amounts up to $100,000. The duration of Phase I will be at least 6 months and no more than 9 months, depending on scheduling constraints. Phase I is to evaluate, insofar as possible, the scientific or technical merit and feasibility of ideas that appear to have commercial potential. The grant application should concentrate on research that will contribute to proving scientific or technical feasibility of the approach or concept. Success in Phase I is a prerequisite to further DOE support in Phase II.

Phase II: Phase II is the principal R&D effort, and only Phase I grantees will be eligible to compete for subsequent Phase II continuation of their Phase I projects. Phase II awards are expected to be made during fiscal year 2003 to firms with approaches that appear sufficiently promising as a result of the Phase I effort. Phase II grant awards are expected to be in amounts up to $750,000 (*nominally $500,000 for STTR*) and to cover a period of up to 24 months. Funds will be allocated over a two-year period. It is anticipated that one-third to one-half of Phase I awardees will receive Phase II awards, depending on Phase I results and availability of funds. Instructions for preparing the Phase II grant application will be provided to all Phase I grantees through a posting on the SBIR/STTR website. The work proposed for Phases I and II, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phase III.

Phase III: Under Phase III, it is intended that non-Federal capital be used by the small business to pursue commercial applications of the R&D. That is, the SBIR/STTR funding pays for research or R&D meeting DOE objectives (Phases I and II); private capital provides follow-on developmental funding to meet commercial objectives (Phase III). Also, under Phase III, Federal agencies may award non-SBIR/STTR funded follow-on grants or contracts for (1) products or processes that meet the mission needs of those agencies, or (2) further research or R&D. In some cases, these follow-on grants or contracts could be sole source awards since they represent a continuation of SBIR or STTR projects that were competitively selected in Phases I and II by scientific/technical review criteria.

1.3 PHASE II COST SHARING AND PHASE III FOLLOW-ON FUNDING

An important goal of these programs is the commercialization of DOE-supported research or R&D. Following the start of Phase I, applicants whose research or R&D has identifiable potential to meet market needs are encouraged to seek commitments from private sector or Federal non-SBIR/STTR funding sources for both Phases II and III. (See Evaluation Criterion 3 in Section 4.3.) **The commitments should be obtained prior to the Phase II grant application submission**. The commitment for Phase III may be made contingent on the DOE-supported research or R&D meeting some specific technical objectives in Phase II, which, if met, would justify funding to pursue further development for commercial purposes in Phase III.

1.4 ELIGIBILITY

Only small businesses, as defined in Section 2.3, are eligible to receive SBIR/STTR awards. Joint ventures as defined in Section 2.7 are also permitted, provided the entity created also qualifies as a small business in accordance with the definition in Section 2.3.

The research or R&D must be performed in the United States for both Phases I and II. "United States" means the 50 states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Trust Territory of the Pacific Islands, and the District of Columbia.

1.5 RESTRICTIONS

1.5.1 Restrictions on Submitting Applications

a. **Choice of Topic and Subtopic**? **Each grant application must be submitted to only one topic and, within it, to only one subtopic** as described in the Technical Topics section. DOE will **not** assign a topic and/or subtopic to grant applications; this must be done by the applicant. When a grant application has relevance to more than one subtopic, the **applicant must decide** which subtopic is the most relevant and submit the grant application under that subtopic only.

b. **Responsiveness**? To be considered responsive, a grant application must fall within the description of the subtopic, and also satisfy any conditions contained in the introductory section of that topic. **The language in both**

the topic introductions and the subtopics should be taken literally. Applications that do not directly address the subtopic statement will be declined for non-responsiveness, and will not be peer reviewed.

c. **Duplicate Applications**? Duplicate grant applications, even if submitted to different topics and/or subtopics, will be rejected without review. The application received first in time will be accepted for evaluation.

d. **Multiple Applications**? There is no limit on the number of **different** grant applications that a small business may submit, even to the same subtopic.

e. **Similar Applications**? Similar grant applications in which some of the tasks overlap (e.g., the same technology used for different purposes), may be submitted. However, **no more than one** such similar grant application will be funded as a result of these solicitations.

f. **Grant Applications Being Considered for Other Funding**? If a grant application submitted in response to these solicitations contains a significant amount of essentially equivalent work as one that has been previously funded by, has been submitted to, or is about to be submitted to, another Federal agency, or to another DOE program, the applicant must so indicate by answering "Y" for yes for Question #4 on the grant application cover page, Appendix A, and by providing the information required by Section 3.3.4. If an award is made pursuant to a grant application submitted under these solicitations, the grantee will be required to certify that neither the grantee organization nor any of its employees have previously been, nor are currently being paid for essentially equivalent work by an agency of the Federal Government.

In the event the same or similar work is selected for funding by two or more agencies, the agencies, in consultation with the applicant, will determine the awarding agency.

1.5.2 Restrictions on the Principal Investigator

The Principal Investigator (PI) is the key individual designated by the applicant to direct the project. The PI must be knowledgeable in all technical aspects of the grant application and be capable of leading the research effort. **Because the DOE's evaluation of the grant application is critically dependent on the qualifications of the PI, changes in the PI that are made after award selection are strongly discouraged. Requests for PI changes will be closely scrutinized and infrequently approved, and may cause delays in grant execution.**

The PI?s primary employment must be with the small business at the time of award and during the conduct of the proposed research. Primary employment means that more than one-half of the PI's time, but no less than 20 hours (average) per week, is spent in the employment of the small business during the conduct of the project. **Primary employment with a small business precludes full-time employment with another organization.** However, it is acceptable for the PI to be on an unpaid leave-of-absence from another organization during the conduct of the research project. In addition, the PI is expected to devote to the project a considerable part of his or her time (at least 150 hours on both SBIR and STTR Phase I projects). Also, the source of the PI's compensation for work on the project must be the small business. In order to ensure appropriate technical guidance for the project, only one PI will be accepted per project; **co-PIs will not be accepted**. Before the grant is awarded, the PI will be required to sign a statement certifying adherence to all these requirements. Sample PI certifications are included at the end of the solicitation for information only. Please do **not** send these samples with the Phase I application.

1.5.3 Restrictions on the Level of Small Business Participation

For both SBIR and STTR, there are requirements on the amount of the funded research or analytical effort that must be performed by the small business (see also Section 3.3.5.a) in order to be selected for and to receive a grant. The funded research or analytical effort is defined as the total requested funding minus the cost of any purchased or leased equipment, materials, and supplies (whether purchased by the applicant or a subcontractor). Work performed by a consultant, a DOE national laboratory, or any other subcontractor, will be considered as external to the applicant organization when complying with these requirements.

To be awarded an SBIR grant, a minimum of two-thirds of the funded research or analytical effort must be allocated to the small business applicant during Phase I; correspondingly, a maximum of one-third of the effort may be allocated to consultants or subcontractors. (In Phase II, up to one-half of the effort may be allocated to consultants or subcontractors).

To be awarded an STTR grant, at least 40% of the funded research or analytical effort must be allocated to the small business, and at least 30% of the effort must be allocated to the non-profit research institution (as defined in Section 2.8). (The same requirement is applicable for both Phase I and Phase II.)

Grant applications that include a substantial amount of cooperative research collaboration with a non-profit research institution can be considered for funding in both programs, thereby increasing the chances of winning an award. The required dollar amount for the research institution (RI) depends on the amount of material, equipment, and supplies in the budget. However, it is unlikely that STTR requirements can be satisfied unless the subcontract for the RI is at least $15,000. Applicants can indicate their interest in being considered for both programs by checking the appropriate box on the grant application cover page, Appendix A. **If you choose to be considered in both programs, prepare the grant application to meet the requirements of the SBIR program.** It is understood that because some requirements differ for the two programs (e.g., the duration of Phase I, the minimum hours for the PI, and the participation levels described above) some scheduling or budgetary adjustments may be required after the grant application is selected for award. These adjustments will be addressed during the negotiation period before the grant begins.

1.5.4 Restrictions on the Management of SBIR/STTR Projects

The small business, not a subcontractor *(including the research institution in STTR)*, must exercise management direction and control of the performance of the SBIR or STTR funding agreement. Regardless of the proportion of the work or funding of each of the performers under the grant, the small business is the primary grantee with overall responsibility for the grant's performance. It is recommended that all agreements between the small business and any subcontractor *(including the research institution collaborating in the STTR project)*, including any business plan concerning agreements and responsibilities between the parties, or for the commercialization of the resulting technology, reflect the controlling position of the small business during the performance of the Phase I or Phase II grant.

1.6 SUPPORT FROM NATIONAL LABORATORIES, UNIVERSITIES, AND OTHER RESEARCH INSTITUTIONS

1.6.1 Identifying Institutions

Experts at institutions such as DOE contractor-operated national laboratories, universities, colleges, or other research institutions, may be consulted during the preparation of the grant application. Any of these institutions may also serve as a subcontractor to SBIR/STTR Phase I or Phase II projects, providing technical expertise, facilities, or equipment. In such cases, the small business must have the necessary expertise to direct the project.

For STTR, the small business must conduct cooperative R&D with a research institution (see Section 2.8). An alliance between the small business and a research institution must be formed before submitting the grant application. Grants will be awarded to the small business, which will receive all funding for the project and disperse the appropriate funds to the research institution.

A list of National Laboratory Collaboration Opportunities is available on our web page at http://sbir.er.doe.gov/sbir under "Advantages of Collaboration". Inquiries may be made at a local library to locate supporting expertise or facilities from an appropriate university or other research institution to assist with the proposed project. For help in contacting personnel at Department of Energy and other Federal agency laboratories, see the Federal Laboratory Consortium (FLC) Website at http://www.federallabs.org or contact the FLC Locator at:

FLC Locator
Mr. Frank Koos or
Mr. Sam Samuelian
950 N. Kings Highway, Suite 208
Cherry Hill, NJ 08034
Phone: (856) 667-7727
FAX: (856) 667-8009
E-mail: fkoos@utrsmail.com
ssamuelian@utrsmail.com

1.6.2 DOE User Facilities

The Department of Energy operates a number of specialized facilities to enable scientists to carry out experiments that could not be done in the laboratories of individuals. These facilities include synchrotron radiation light sources (Advanced Light Source, National Synchrotron Light Source, Advanced Photon Source, and Stanford Synchrotron Radiation Laboratory), high-flux neutron sources (High Flux Beam Reactor, Intense Pulsed Neutron Source, High Flux Isotope Reactor, and Neutron Scattering Center), electron-beam microcharacterization centers (Center for the Microanalysis of Materials, Electron Microscopy Center, Shared Research Equipment Program, and National Center for Electron Microscopy), particle and ion accelerators (Relativistic Heavy Ion Collider, Continuous Electron Beam Accelerator Facility, Argonne Tandem Linac Accelerator System, Lawrence Berkeley National Lab 88-Inch Cyclotron, Holifield Radioactive Ion Beam Facility, the Bates Linear Accelerator Center at MIT), and other specialized facilities (Surface Modification & Characterization Research Center, Combustion Research Facility, James R. MacDonald Laboratory, Pulse Radiolysis Laboratory, and Materials Preparation Center).

Potential applicants to the SBIR or STTR programs should consider whether the use of these facilities would contribute to the scientific efforts proposed in Phases I or II. For approved experiments (access to these facilities is through a peer-reviewed system), operating time is available without charge to those scientists whose intent is to publish their results in the open literature. If the investigator wishes to perform proprietary research, the user must pay the full-cost recovery rate for facility usage (in which case, the cost could be charged to the SBIR/STTR project); in return, the facility will treat all technical data generated as proprietary, and the user may take title to any inventions resulting from the research. Additional details on program dedicated user facilities may be found at the following websites: http://www.er.doe.gov/production/bes/BESfacilities.htm for facilities supported by the Office of Basic Energy Sciences, http://www.sc.doe.gov/production/ober/facilities.html for facilities supported by the Office of Biological and Environmental Sciences. Information on other laboratory facilities which may be available on a case by case basis may be obtained through the FLC Locator or directly from the DOE laboratory involved.

1.7 AGREEMENTS WITH RESEARCH INSTITUTIONS AND OTHER SUBCONTRACTORS

1.7.1 Property and Commercialization Rights Agreements

It is in the small business's best interest, when collaborating with a research institution or other subcontractor, to negotiate a written agreement for allocating, between the parties, intellectual property rights and rights to carry out any follow-on research, development, or commercialization. *For STTR awards only, the small business and the research institution must certify that this agreement has been completed. This certification will be requested by the Contracts Specialist after award selection, but before the grant is signed.* The model agreement provided at the end of this document may be used or revised through negotiation between the small business and the research institution. The completed agreement should **not** be submitted with the grant application, but retained by the parties to the agreement.

The Federal government will not be a party to any agreement between the small business and any subcontractor, including the STTR research institution. However, applicants are reminded that nothing in such agreements should conflict with any provisions setting forth the respective rights of the United States and the small business with respect to both intellectual property rights and any rights to carry out follow-on research.

1.7.2 Cooperative Research and Development Agreements

SBIR/STTR grant recipients who choose a DOE laboratory as a subcontractor may be required to implement a Cooperative Research and Development Agreement (CRADA). CRADAs are collaborative research agreements between DOE laboratories and their partners, and are approved by the appropriate DOE Operations Office. *In many cases, the CRADA could be used as a vehicle for the property and commercialization rights agreement required by the STTR program (Section 1.7.1).*

Immediately after the applicant small business is notified that it has been chosen for an SBIR/STTR grant award, the company should contact the laboratory to determine if a CRADA will be required. If the DOE laboratory requires a CRADA, no work may be initiated by the laboratory under the grant until the CRADA has been approved.

Implementation of a CRADA begins with project definition and milestones, and leads to a statement of work. Standard terms and conditions, with a total of 60 options to provide maximum flexibility, are available from the laboratory for use by partners and laboratories. A streamlined, short-form

CRADA document that can reduce the need for legal review is also available.

1.7.3 Work-for-Others Agreements

"Work-for-Others" agreements are used by DOE national laboratories when performing tasks that are less cooperative in nature than tasks that require a CRADA (i.e., the work is directed by the primary contractor rather than being fully collaborative). Nonetheless, it is recommended, even when operating under a work-for-others agreement, that the small business negotiate a written agreement for the disposition of intellectual property that laboratory employees may develop during the course of their work for the grantee.

1.7.4 When to Negotiate these Agreements

It is recommended that small business applicants to the SBIR/STTR programs attempt, to the maximum extent practicable, to negotiate these agreements before submitting the grant application. It is during this period that the small business will have maximum leverage in conducting negotiations. If satisfactory terms cannot be agreed upon at this time, the small business still would have the option of finding an alternative research institution or subcontractor. Once the grant application has been submitted to the DOE, and subsequently reviewed and selected for award, the small business may be locked-in to the subcontractor identified in the grant application. Also, after selection for award, there would only be a short time available for conducting these negotiations before the grant would begin.

1.8 CONTACT WITH DOE

Questions about the DOE SBIR/STTR programs may be addressed to the SBIR/STTR Program Office, SC-32, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290, telephone (301) 903-1414, e-mail: sbir-sttr@science.doe.gov. Requests to be added to the notification list for future DOE SBIR/STTR solicitations should be forwarded to the SBIR/STTR Program office as mentioned above, by calling the DOE SBIR/STTR hotline on (301) 903-5707, or by submitting your request on-line at the SBIR/STTR website: http://sbir.er.doe.gov/sbir. For reasons of competitive fairness, communications with DOE personnel regarding this solicitation are limited to non-technical matters and to clarifying specific language in the solicitation. Further interpretations of the narrative descriptions of the technical topics will not be provided. However, the staff of DOE national laboratories, universities, or other research institutions may provide assistance, or may even enter into an agreement to participate in a grant application, as described in Section 1.6.

No information on grant application status will be available until the final selections have been made (approximately four months after the closing date of the solicitation). However, if a grant application acknowledgment, with an assigned grant application number, is not received from DOE within three weeks of the closing date, the applicant should telephone (301) 903-1414.

2. DEFINITIONS

The following definitions apply for purposes of this solicitation:

2.1 RESEARCH OR RESEARCH AND DEVELOPMENT

Research or R&D is any scientific or engineering activity which is (1) a systematic, intensive study directed toward greater knowledge or understanding of the subject; (2) a systematic study directed specifically toward applying new knowledge to meet a recognized need; and/or (3) a systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

2.2 INNOVATION

Innovation is the process of introducing new ideas into use, or the process of introducing novel uses of existing ideas.

2.3 SMALL BUSINESS CONCERN

A small business concern is one that at the time of award of Phase I (and of Phase II, if awarded):

a. Is independently owned and operated, has its principal place of business located in the United States (as defined in Section 1.4), and is organized for profit;

b. Is at least 51 percent owned, or in the case of a publicly owned business, has at least 51 percent of its voting stock owned by United States citizens or lawfully admitted permanent resident aliens; and

c. Has, including its affiliates, a number of employees not exceeding 500. Business concerns, other than licensed investment companies or state development companies qualifying under the Small Business Investment Act of 1958, 15 U.S.C., Chapter 14B Small Business Investment Program, Section 661 et seq., are affiliates of one another when either, directly or indirectly, (1) one concern controls or has the power to control the other, or (2) third parties (or party) control or have the power to control both. Control can be exercised through common ownership, common management, and contractual relationship. Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association, or cooperative.

2.4 SOCIALLY AND ECONOMICALLY DISADVANTAGED SMALL BUSINESS CONCERN

A socially and economically disadvantaged small business concern is one:

a. that is at least 51 percent owned by (i) an Indian tribe or a native Hawaiian organization, or (ii) one or more socially and economically disadvantaged individuals; and;

b. whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals. A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent Asian Americans, other groups designated from time to time by the Small Business Administration (SBA) to be socially disadvantaged, or any other individual found to be socially and economically disadvantaged by SBA pursuant to section 8(a) of the Small Business Act, 15 U.S.C. 637(a).

Related information requested in Appendix D, "Application Checklist," is provided to the Small Business Administration for statistical purposes and is not considered in the evaluation of grant applications or award of grants.

2.5 WOMAN-OWNED SMALL BUSINESS CONCERN

A woman-owned small business concern is a small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management.

Related information requested in Appendix D, "Application Checklist," is provided to the Small Business Administration for statistical purposes and is not considered in the evaluation of grant applications or award of grants.

2.6 SUBCONTRACT

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by the primary recipient of a Federal Government grant, calling for supplies or services required solely for the performance of the original grant award.

2.7 JOINT VENTURE

A joint venture is an association between two or more firms to participate jointly in a single business enterprise. There must be a community of interests, a sharing of profits and losses, and, for the purposes of this solicitation, the new entity must qualify as a small business concern as defined in Section 2.3. If a joint venture is selected for award, the Contract Specialist from the Contracting Office will request a signed agreement from the parties involved. The agreement must state which company will negotiate the grant and serve as the main point of contact.

2.8 RESEARCH INSTITUTION

A research institution is a U.S. research organization that is:

a. A non-profit research institution as defined in section 4(5) of the Stevenson-Wydler Technology Innovation Act of 1980 (i.e., an organization owned and operated exclusively for scientific or educational purposes, no part of the net earnings of which inures to the benefit of any private shareholders or individual), or

b. A non-profit college or university, or

c. A non-profit medical or surgical hospital, or

d. A **contractor-operated** federally-funded research and development center (FFRDC), as identified by the National Science Foundation in accordance with the government-wide Federal Acquisition Regulations issued in accordance with section 35(c) (1) of the Office of Federal Procurement Policy Act (or any successor legislation thereto). Department of Energy FFRDCs include Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Idaho National Engineering Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, National Renewable Energy Laboratory, Oak Ridge Institute for Science and Education, Oak Ridge National Laboratory, Pacific Northwest Laboratory, Princeton Plasma Physics Laboratory, Sandia National Laboratories, Savannah River Technology Center, Stanford Linear Accelerator Center, and the Thomas Jefferson National Accelerator Facility.

e. A government-owned, government-operated facility, such as the National Energy Technology Laboratory (NETL), is **not** eligible to act as either a partner or subcontractor in DOE SBIR/STTR projects.

3. PREPARATION INSTRUCTIONS AND REQUIREMENTS FOR GRANT APPLICATIONS

3.1 GENERAL REQUIREMENTS

Grant applications, submitted to DOE under SBIR/STTR programs, must provide sufficient information to convince DOE, and members of the research community who review the grant application, that the application is responsive to the topic and subtopic under which it is submitted, that the proposed work represents a sound approach to the investigation of an important scientific or engineering question, and that it is worthy of support under the stated criteria. The grant application should describe self-contained research that will contribute to proving scientific or technical feasibility of the approach or concept. It should be written with the care and thoroughness accorded papers for publication--direct, concise, and informative. Promotional and non-project-related discussion detracts from the professional quality of the proposal. The work proposed for Phase I, assuming that it proceeds successfully, should be suitable in nature for subsequent progression to Phases II and III.

Technical reviewers will base their conclusions only on information contained in the 25 pages of the grant application. Do not assume that reviewers are acquainted with the small business, key individuals, or any theory or experiments referred to, but not described. (This includes material in refereed professional journals--those in which the articles have been subjected to peer review, and material referenced on internet web pages). Relevant journal articles should be summarized in the grant application. Attached videos, CDs, other media, or printed material beyond the 25-page limit, will not be reviewed.

Specifically excluded from this solicitation are grant applications principally for literature surveys, for compilations of the work of others, for technical assessments, or for technical status surveys. If any of these types of tasks are included in the work plan, the grant (if awarded) may be reduced in proportion to that effort. In addition, grant applications primarily for the development of already proven concepts will be declined, because such efforts are considered the responsibility of the private sector.

Narrative descriptions of 45 technical topics are provided in the Technical Topics section. Each technical topic is subdivided into a maximum of 4 subtopics, designated by the letters a, b, c, or d. **A grant application must respond to a specific technical topic and, within it, to only one subtopic, as required in Section 1.5.1.b**. For example, an applicant submitting a grant application to topic 4a may not submit the same grant application to any other topic and subtopic.

3.2 25-PAGE LIMITATION

Grant applications are limited to 25 consecutively numbered pages stapled together, including cover page, project summary page, main text, references, resumes, budget, and any other enclosures or attachments. The checklist (Appendix D) and the budget worksheet (Appendix D backside) are not included in the 25-page limitation. VCR tapes, CDs, or electronic disks will not be accepted. Grant applications containing more than 25 pages will not be considered for review or award. **The pages must be of standard 81/2" x 11" size (21.6 cm x 27.9 cm). For proportionally spaced fonts, the type can be no smaller than 12 point, and for non-proportionally-spaced fonts, the type can be no smaller than 12 characters per inch (elite). Margins are not to be less than 1 inch (2.5 cm).** The listing of multiple Phase II awards, which may be required by Section 3.3.7, is exempted from the 25-page limitation.

3.3 PHASE I GRANT APPLICATION FORMAT

The items listed in this section should be covered fully and in the order set forth. In following this format, applicants should keep in mind that their grant application will be evaluated with respect to the criteria listed in Section 4.2. The application should be written so as to convince the technical reviewers that each of the criteria has been met to a high degree.

3.3.1 Introductory Pages

a. **Cover Page** ? ? Complete the form identified as Appendix A in the solicitation. Detailed instructions are provided on the back of Appendix A. This is to be the first page on each of the required 6 copies and one original of your grant application. No other cover page is permitted. Please do not use plastic or other heavy material covers or bindings as they slow processing of your application.

Both the topic number and subtopic letter must **be entered in the appropriate spaces** on the cover page. **<u>Failure to identify both the topic and subtopic on the cover page will cause the grant application to be declined without further review.</u>**

Be sure to answer the yes/no question about collaboration with a research institution. For those that check "yes," you must indicate whether the grant application should be considered for SBIR, STTR, or both programs. For grant applications that are to be considered for both SBIR and STTR, refer to Section 1.5.3. for guidance with respect to conforming to the separate requirements for the two programs.

Applicants must provide answers to all six Certifications and Questions. An answer of "Yes" to Certifications 1 through 3 is required. If the DOE learns from any source that any of these certifications were completed fraudulently, appropriate authorities will be notified for possible criminal investigations.

Signatures of the Principal Investigator and the Corporate/Business Authorized Representative are mandatory. Also, for those grant applications that have significant collaboration with a research institution *(including all grant applications to be considered for STTR),* a signature is required from a person authorized to commit the research institution to participate in the project described in the grant application.

b. **Project Summary ? ?** Complete the project summary form identified as Appendix B, and include it as Page 2 of your application. Since this summary may be made public by DOE, **do not include proprietary information on this page**. This form should be neat, clean, and typewritten.

The purpose of the technical abstract is to communicate the overall sense of the project, not every step of the work plan. Statements of future applications or benefits belong in the section on Commercial Applications and Other Benefits. **Do not use acronyms, abbreviations, first-person references, or any proper names (including the name of the small business), any subcontractors or institutions, or any trade or product name.**

The Department notifies members of Congress of awards in their districts. Therefore, please provide, in clear and concise **layman's** terms, a very brief summary of the project (maximum 2 sentences, 50 words), suitable for a possible press release from a Congressional office. **Suggested Format:** First Sentence--State the problem being addressed so that the DOE interest is clear. Second Sentence--State what is being done to address the problem.

3.3.2 Significance and Background Information, and Technical Approach

a. **Identification and Significance of the Problem or Opportunity, and Technical Approach ? ?** (Begin on page 3 of your grant application.) Define the specific technical problem or opportunity addressed by your application. Provide enough background information so that the importance of the problem/opportunity is clear. Indicate the overall technical approach to the problem/opportunity and the part that the proposed research plays in providing needed results.

b. **Anticipated Benefits ? ?** Discuss the technical, economic, social, and other benefits to the Nation, if the project is successful and is carried over into Phases II and III. Identify specific groups in the commercial sector or the Federal government that would benefit from the projected results. Describe the resultant product or process, the likelihood that it could lead to a marketable product, and the significance of the market.

3.3.3 The Phase I Project

a. **Technical Objectives** ? ? State the **specific** technical objectives of the Phase I effort, including the questions it will try to answer to determine the feasibility of the proposed approach.

b. **Phase I Work Plan ? ? Provide an explicit, detailed description of the Phase I research approach and work to be performed**. Indicate what will be done, by whom (small business, subcontractors, or consultants), where it will be done, and how the work will be carried out. The Phase I effort should attempt to determine the technical feasibility of the proposed concept which, if successful, would provide a firm basis for the Phase II grant application.

Link the work plan to the objectives of the proposed project. Discuss the methods planned to achieve each objective or task explicitly and in detail. **This section should be a substantial portion of the total grant application**.

Phase I Performance Schedule ? ? Briefly describe the important milestones and the estimated percentage of time for completing each task described in the work plan.

c. **Related Research or R&D ? ?** Demonstrate knowledge of key recent work conducted by others in the specific area of the proposed project. If not already addressed in Sections 3.3.2.a, or 3.3.3.b, describe significant research that is directly related to the grant application, including any conducted by the Principal Investigator or by the applicant organization. Describe how it relates to the proposed effort and any planned coordination with outside sources.

d. **Principal Investigator and other Key Personnel** The Principal Investigator (PI) must be knowledgeable in all technical aspects of the grant application and be capable of leading the research effort. A resume of the PI, including a list of publications (if any), must be included. It is important that the requirements described in Section 1.5.2 concerning the PI be met explicitly. Also identify other key senior personnel involved in the Phase I effort including information on directly related education and experience. List relevant publications by key personnel.

e. **Facilities/Equipment** ? ? Describe available equipment and physical facilities necessary to carry out the Phase I effort. Equipment is defined as an article of tangible, nonexpendable, personal property, including exempt property, charged directly to the award, having a useful life of more than one year, and an acquisition cost of $5000 or more per unit. Items of equipment to be leased or purchased must be described and justified in this section. Title to equipment purchased with SBIR/STTR funds may be vested with the grantee at DOE's option. Awardees wishing to obtain title should contact their Contract Specialist for the procedure to follow.

If the equipment, instrumentation, and facilities are not the property of the applicant and are not to be purchased or leased, **the source must be identified and their availability and expected costs specifically confirmed in this section**. A principal of the organization that owns or operates the facilities / equipment must certify regarding the availability and cost of facilities/equipment and any associated technician cost; a copy of this certification must be submitted as part of the grant application.

To the extent possible in keeping with the overall purposes of the program, only American-made equipment and products should be purchased with financial assistance provided under both Phase I and Phase II awards.

f. **Consultants and Subcontractors**

(i) **Research Institution --** If the grant application contains substantial collaboration with a research institution *(required for STTR)*, (1) identify the research institution and (2) describe in detail the work to be done by this institution in the Work Plan section. The research institution will be a subcontractor to the small business applicant. A research institution official's signature on the cover page commits the institution to participate in the project as described in the grant application.

(ii) **Other Consultants and Subcontractors? ??** Involvement of consultants or subcontractors in the planning and research stages of the project is permitted **provided the work is performed in the United States** and subject to the limitations in Section 3.3.5.a. If consultants and/or subcontractors are to be used, this section must identify them and should reference "Letters of Commitment" provided to the applicant by the consultants and/or subcontractors and submitted as part of the application. The letters must provide the proposed costs for the consultant or subcontractor, as well as a specific statement certifying that they have agreed to serve in the manner and to the extent described in the Work Plan section of the grant application. Each letter must be signed by the consultant him/herself, or, for a subcontractor, by an individual authorized to represent the subcontractor. Note: Consultants are not employees of either the small business or any subcontractor.

3.3.4 Similar Grant Applications, Proposals, or Awards

While it is permissible, with notification in the proposal or grant application, to submit identical proposals or proposals containing a significant amount of essentially equivalent work to more than one federal agency, it is unlawful to enter into contracts or grants in which essentially equivalent efforts are performed. If a grant application contains work that has been previously funded, or is either funded, pending, or about to be submitted to another Federal agency or to the DOE in a separate action, the applicant must provide the following information in the grant application:

- The name and address of the agency(s) to which a proposal or grant application was submitted, or will be submitted, or from which an award is expected or has been received.
- The date of submission or the date of award.
- The title of the grant application.
- The name and title of the project manager or Principal Investigator for each proposal or grant application submitted or award received.
- The number and date of the solicitation under which the application or award was received.
- The title of the specific research topic to which the application or award was submitted.

In the event that a proposal or grant application is selected for award by more than one agency, a negotiation will be conducted among the parties to avoid duplication of effort.

3.3.5 Budget

Complete the Grant Application Budget form, Appendix C, for the Phase I effort only. Incorporate the copy of the budget form that bears the original signature into the copy of the grant application that bears the original signatures on the cover page. **The budget form should be the last page of the grant application.** No other budget form is permitted. A sample budget page is provided along with Appendix C.

a. **Under SBIR Phase I, a minimum of two-thirds of the funded research or analytical effort must be performed by the proposing firm. (In Phase II, the minimum is one-half.)** ***For STTR, Phases I and II, a minimum of 40% of the funded research or analytical effort must be performed by the small business, and at least 30% of the work must be performed by the research institution.*** The funded research or analytical effort is defined as the total requested funding minus the cost of any purchased or leased equipment, materials, and supplies (whether purchased by the applicant, the research institution, or any other subcontractor). For grant applications that are to be considered for both SBIR and STTR, refer to Section 1.5.3. for guidance with respect to conforming to the separate requirements for the two programs. A worksheet is provided on the reverse side of the Checklist (Appendix D) to assist in calculating the percent of the funded research and analytical effort allocated to each participant. **This worksheet must be completed and submitted with the grant application.** A completed example is also provided, following Appendix D. Applicants are encouraged to contact the SBIR/STTR office if there are questions about this worksheet (301-903-0569).

b. Although there is no absolute cap on indirect costs, grant applications will be evaluated for overall economy and value to DOE.

c. All key small business personnel participating in the Phase I project must be identified in Section A of the budget form. None of the small business personnel can also be consultants or employees of a subcontractor.

d. The principal investigator must spend a minimum of 130 hours (*195 hours for STTR*) on the project (see Section 1.5.2).

e. Use Section B of the budget form to identify consultants. Consultants are not employees of either the small business or any subcontractor *(including the research institution for STTR)*. Consultant costs are not considered part of the small business's research or analytical effort (Section 3.3.5a).

f. Equipment budgets may be included under Phase I (and Phase II). Equipment to be leased or purchased by the small business should be listed in sections C and D and will be carefully reviewed relative to need and appropriateness for the research or R&D proposed. Equipment is defined as an article of tangible, nonexpendable, personal property, including exempt property, charged directly to the award, having a useful life of more than one year and an acquisition cost of $5000 per unit or more.

g. Travel funds, line E, must be justified and related **to the needs of the project**. Travel expenses for technical conferences are not permitted unless the purpose of attending the conference directly relates to the project (e.g., to present results of the project). **Foreign travel is not an appropriate expense.**

h. In Section F, include only items which are to be acquired from outside the small business. Identify the research institution, if any, on line F5 and any other subcontractors on line F6. On line F6, identify separately the amount of subcontract work to be performed by each subcontractor. A detailed budget for each subcontract should be described on a separate "Budget Explanation Page." In particular, the amount of any equipment, materials, and supplies to be purchased or leased by each subcontractor must be identified on the Budget Explanation page.

i. Phase I (and Phase II) grants may include a profit or fee for the small business, and this amount should appear on line J.

j. **If the total cost of the project (Line I plus Line J) exceeds the amount requested, the grant application must contain information on who will contribute the difference.** This difference should be reported on Line K as cost sharing. Line L (amount of request) must match the amount requested on the cover page, and cannot exceed $100,000. Note that any cost share must be an allowable cost (see Section 3.3.5.l).

k. Tuition costs are not acceptable costs and should not be included in the budget.

l. The government will pay only allowable costs. These are available from the World Wide Web at site http://www.arnet.gov/far/loadmain.html or a copy may be purchased from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954. Telephone: 202-512-1800. Fax: 202-512-2250. Supporting information for proposed costs may be requested by the contracting office to negotiate the grant.

Note: if your application is accepted for award, the contracting office may need additional supporting information. That office will provide you with specific instructions regarding the information to be submitted.

3.3.6 Certifications

If selected for an award, applicants may be requested to sign and submit one or more of the following certifications directly to the DOE Contract Specialist **during award negotiation**.

a. Principal Investigator Certification
b. Assurance of Compliance
c. Lobbying, Debarment, Suspension, and Other Responsibility Matters and Drug Free Workplace Requirements
d. Property and Commercialization Rights Agreement

For your information and convenience, samples of these certifications are included in the Certifications Section at the end of this solicitation. **Do not include them with the application.**

3.3.7 Addendum: Documentation of Multiple SBIR Phase II Awards

Public Law 102-564 requires that a small business that submits an SBIR Phase I grant application and has received more than 15 Phase II SBIR awards, as totaled from all Federal agencies with SBIR programs, during the preceding five fiscal years, must document the extent to which it was able to secure Phase III funding to develop concepts resulting from previous Phase II awards. Accordingly, such small business concerns shall submit, for each SBIR Phase II award, the name of the awarding agency, the date of the award, the funding agreement number, the funding amount, the topic or subtopic title, the amount of follow-on funding, the source and the date that the follow on funding was provided, and the current commercialization status. **This required information will not be counted toward the grant application limitation of 25 pages,** and should be prepared on a separate page with the heading "Addendum--Phase II History." **Only one copy is necessary**, and it should be attached to the original application.

3.3.8 Checklist and Statistical Information

Complete both sides of the Checklist in Appendix D and submit one copy with the grant application. **The Checklist will not be counted in the 25-page limitation of the grant application.** Read this checklist carefully to assure that a submission is not declined for administrative or budgetary reasons which could have been prevented. The reverse side of the Checklist is to assist the applicant in complying with the level of effort requirements discussed in Section 3.3.5.a.

Be sure to complete the statistical information at the bottom of the Checklist form (Appendix D). This information is required by the Small Business Administration for statistical purposes, will not be revealed to the reviewers, **and will play no role in the grant application award process**.

4. METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 INTRODUCTION

Phase I grant applications will be judged on a competitive basis in several stages. All will be screened initially by DOE to ensure that they (1) meet stated solicitation requirements, (2) are responsive to the topic and subtopic entered on the cover page (see definition of responsiveness in Section 1.5.1), (3) contain sufficient information for a meaningful technical review, (4) are for research or for research and development, and (5) do not duplicate other previous or current work. Grant applications which fail to pass the initial screening will be declined without further review.

Grant applications found to be in compliance with those requirements will be evaluated technically by scientists or engineers to determine the most promising technical and scientific approaches. Each grant application will be judged competitively against the Phase I evaluation criteria (see Section 4.2) on its own merit. Final decisions will be made by DOE based on the evaluation criteria and consideration of other factors, such as program balance and needs.

4.2 EVALUATION AND SELECTION CRITERIA? PHASE I

DOE plans to select awards from those grant applications judged to have the highest overall merit within their technical subject area, with approximately equal consideration given to each of the following criteria:

1. Strength of the Scientific/Technical Approach as evidenced by (1) the innovativeness of the idea and the approach, (2) the significance of the scientific or technical challenge, and (3) the thoroughness of the presentation.

2. Ability to Carry out the Project in **a Cost Effective Manner** as evidenced by (1) the qualifications of the Principal Investigator, other key staff, and consultants, if any, and the level of adequacy of equipment and facilities; (2) the soundness and level of adequacy of the work plan to show progress toward proving the feasibility of the concept; and (3) the degree to which the DOE investment in the project would be justified by the level of proposed research effort.

3. Impact as evidenced by (1) the significance of the technical and/or economic benefits of the proposed work, if successful, (2) the likelihood that the proposed work could lead to a marketable product or process, and (3) the likelihood that the project could attract further development funding after the SBIR or STTR project ends.

The DOE will not fund any grant application for which there is a reservation with respect to any of the three evaluation criteria, as determined by the review process. In addition, because the DOE supports only high quality research and development, grant applications will be considered candidates for funding only if they receive strong endorsements with respect to at least two of the three criteria. From those grant applications considered candidates for funding, each of the participating DOE program areas will select up to a pre-determined number for funding. (The pre-determined number is proportional to a program area?s contribution to the SBIR/STTR programs.) Therefore, grant applications are largely in competition with other grant applications submitted to technical topics from the same DOE technical program area.

4.3 EVALUATION CRITERIA? PHASE II

Detailed instructions regarding Phase II grant application submission will be provided by DOE to all Phase I awardees. A Phase II grant application can be submitted only by a DOE Phase I awardee. It must contain enough information on progress accomplished under Phase I by the time of Phase II grant application submission to evaluate the project's promise if continued into Phase II. The Phase II grant application will be evaluated based on the equally weighted criteria below.

1. Strength of the Scientific/Technical Approach as evidenced by (1) the strength and innovativeness of the overall idea and approach for the combined Phase I/Phase II project, (2) the significance of the scientific or technical challenge, and (3) the thoroughness of the presentation.

2. Ability to Carry Out the Project in a Cost Effective Manner as evidenced by (1) the qualifications of the Principal Investigator, other key staff, consultants, if any, and the level of adequacy of equipment and facilities; (2) the soundness and level of adequacy of the work plan to meet the problem or opportunity; (3) with regard to the Phase I objectives, the degree to which Phase I has proven feasibility of the concepts; and (4) the degree to which the DOE investment in the project would be justified by the level of proposed research effort.

3. Impact as evidenced by (1) the significance of the technical and/or economic benefits of the proposed work, if successful, (2) the likelihood that the proposed work could lead to a marketable product or process, and (3) the likelihood that the project could attract further development funding after the SBIR or STTR project ends. The following evidence of commercial potential will also be considered: (a) the small business concern's record of commercializing SBIR, STTR, or other research, (b) Phase II funding commitments from private sector or non-SBIR/STTR Federal funding sources, and (c) Phase III follow-on funding commitments for the subject of the research.

Phase II grant applications will be subject to a technical review process similar to Phase I. Grant applications will be judged against Phase II criteria on a competitive basis. Final decisions will be made by DOE based on the evaluation criteria and consideration of program balance and needs.

The Phase II funding commitment described above should be an additional 20 percent or more of the Phase II funding requested from the DOE in order to receive full credit. Smaller commitments will receive partial credit. The commitment must be provided either to or by the small business during the Phase II project period. Contributions from international companies are allowed for Phase II non-SBIR/STTR follow-on funding contributions. In-kind contributions are acceptable provided the commitment is in writing, signed by a responsible official, and includes a dollar estimate of its value.

The Phase III follow-on funding commitment must provide that a specific amount of funds (at least one-half of that amount requested from DOE for Phase II) will be made available to or by the small business. Smaller commitments will receive partial credit. The commitment must be **signed** by a person with the authority to make it, indicate the **dates** the funds will be made available, and contain specific **technical objectives** which, if achieved in Phase II, will make the commitment exercisable by the applicant. The terms cannot be contingent on obtaining a patent because of the length of time that process requires. Commitments by private sector firms to purchase items developed under Phase II are acceptable provided the commitment is in writing, signed by responsible official, and includes a dollar estimate of its value.

5. CONSIDERATIONS

5.1 AWARDS

SBIR and STTR awards are subject to the availability of funds and this solicitation does not obligate DOE to make any awards under either Phase I or Phase II. For those grant applications chosen for awards, recipients may incur pre-award costs up to ninety days prior to the effective date of the award, but any pre-award expenditures are made at the recipient's risk. Approval of pre-award costs by the Contract Specialist or incurrence by the recipient does not impose any obligation on DOE if an award is not subsequently made, or if an award is made for a lesser amount than the recipient expected.

Phase I ? ? From this solicitation, DOE expects to award approximately 215, fixed obligation Phase I research grants ranging up to $100,000 to small businesses in fiscal year 2002. Selections of awards will be completed approximately four months after the closing date of the solicitation. At that time, DOE will notify all applicants of the results and announce the names of those firms receiving awards. Grants are expected to begin about July 22, 2002. The duration of Phase I will be at least 6 months and no more than 9 months, depending on scheduling constraints.

Phase II ? ? It is anticipated that one-third to one-half of the Phase I awardees will receive Phase II awards, depending on the results of the Phase I effort and the availability of funds. SBIR Phase I awardees may request up to $750,000 for Phase II *($500,000 is the nominal limit for STTR for Phase II)*. The period of performance under Phase II will depend on the scope of the effort, but normally will not exceed 24 months.

Successful Phase II applicants will be issued a grant amendment covering a four-month interim period of performance while the Phase II effort is being negotiated. Should the two parties fail to agree on terms covering the Phase II effort, allowable costs incurred during the four-month interim period will be paid in accordance with Federal and DOE commercial cost principles. (See FAR, Part 31, at http://www.gsa.gov/far/90-46/html/31PART.HTM, and DEAR, Subpart 931, at http://www.pr.doe.gov/dear.html.)

5.2 REPORTS AND PAYMENTS

Final Reports -- Three copies of a final technical report on the project must be submitted to DOE within 90 days after the performance of the effort ends. Therefore, the final report is due:

- 90 days after the Phase I project period ends if a Phase II application was not submitted; or
- 90 days after notification of non-selection for a Phase II award if a Phase II application was submitted; or
- 90 days after the Phase II project period ends.

One copy should be sent to the DOE Technical Project Manager and two copies to the Contract Specialist of the Contracting Office which negotiated the grant

The final report should include a single-page project summary as the first page (use Appendix B form or a similar format) identifying the purpose of the research, a brief description of the research carried out, the research findings, and the commercial applications and other benefits of the research in a final paragraph. DOE may publish the summary so it must not contain proprietary information. The remainder of the report should indicate in detail the project objectives, work carried out, results obtained, and estimates of technical feasibility. The Final Technical Report shall be marked in accordance with the clause entitled "Rights in Data – SBIR/STTR Program" of the grant.

Payment Procedures ? ? Details of payment procedures will be provided by the DOE Contract Specialist if a grant is issued. Fixed-obligation grants will be issued for Phase I awards. Incremental funding over a 24-month period will be used with Phase II grants. **Do not send invoices to the DOE Headquarters SBIR/STTR program**; use the address provided by the Contract Specialist.

5.3 RESEARCH INVOLVING SPECIAL CONSIDERATIONS

If the proposed research involves human subjects or vertebrate animals, the following regulations will apply:

a. **Human Subjects ? ?** Guidelines to be used in safeguarding the rights and welfare of human subjects used in research supported by the Department of Energy are contained in Ch. 10, Part 745 of the Code of Federal Regulations (CFR) available on the internet at http://www.access.gpo.gov/nara/cfr/waisidx/10cfr745.html.

b. **Animal Welfare ? ?** Research work funded by the Department of Energy must be in compliance with the Animal Welfare Act of 1966, as amended (7 U.S.C. 2131 et seq), (9 CFR Part 1, 2, and 3).

If the proposed scientific research involves human subjects or vertebrate animals, attach a note to that effect to the Checklist, (Appendix D). (The note will not count in the page limit.) If the grant application is selected for award, the SBIR/STTR office will provide information regarding additional approvals which must be obtained prior to award.

5.4 INTELLECTUAL PROPERTY INCLUDING INNOVATIONS, INVENTIONS, AND PATENTS

a. **Proprietary Information**. Information contained in unsuccessful grant applications will remain the property of the applicant. The Government will retain one file copy of each unsuccessful grant application and destroy the remainder. Public release of information in any grant application submitted will be subject to existing statutory and regulatory requirements, such as the Freedom of Information Act.

If proprietary information is provided in a grant application that constitutes proprietary technical data, confidential personnel information, or proprietary commercial or financial information, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the applicant with the term "Confidential Proprietary Information" and provided appropriate page numbers are inserted into the Proprietary Notice legend printed at the bottom of the cover page (Appendix A). The Government will limit dissemination of such information to official channels. Any other legend may be unacceptable to the Government and may constitute grounds for removing the grant application from further consideration and without assuming any liability for inadvertent disclosure.

b. **Protection of Grant Application Information**. DOE's policy is to use data included in grant applications for evaluation purposes only and to protect such information from unauthorized use or disclosure.

In addition to government personnel, scientists and engineers from outside the Government may be used in the grant application evaluation process. The decision to obtain outside evaluation will take into consideration requirements for the avoidance of organizational conflicts of interest and the competitive relationship, if any, between the applicant and the prospective outside evaluator. The evaluation will be performed under an agreement with the evaluator that the information contained in the grant application will be used only for evaluation purposes and will not be further disclosed.

c. **Rights in Data Developed Under SBIR/STTR Funding Agreements**. Rights in technical data, including software developed under the terms of any funding agreement resulting from grant applications submitted in response to this solicitation, shall remain with the grantee, except that the Government shall have the limited right to use such data for Government purposes and shall not release such proprietary data outside the Government without permission of the grantee for a period of not less than four years from completion of the project from which the data were generated. However, effective at the conclusion of the four-year period, the Government shall retain a royalty-free license for Government use of any technical data delivered under an SBIR/STTR award whether patented or not and shall be relieved of all disclosure prohibitions.

d. **Copyrights**. With prior written permission of the Contract Specialist, the awardee may copyright and publish (consistent with appropriate national security considerations, if any) material developed with DOE support. DOE receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

e. **Patents**. Small businesses may retain the principal worldwide patent rights to any invention developed with Federal support. The Government receives a royalty-free license for Federal use, reserves the right to require the patent holder to license others in certain circumstances, and requires that anyone exclusively licensed to sell must normally manufacture it domestically. Information regarding patent rights in inventions supported by Federal funding can be found in the Code of Federal Regulations, 37 CFR Part 401.

f. **Distribution of Intellectual Property and Commercialization Rights Between the Small Business and Subcontractor.** When using subcontractors, including research institutions, the small business is responsible for protecting its own interests with regard to the retention of intellectual property and commercialization rights. The negotiation of written agreements for assigning these rights is recommended and discussed in Section 1.7.

5.5 NONDISCRIMINATION IN FEDERALLY ASSISTED PROGRAMS

In accordance with Title VI of the Civil Rights Act of 1964, P.L. 88-352, the applicant organization responding to this solicitation must agree to ensure that no person in the United States shall, on the grounds of race, color, national origin, sex, age, or handicap, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity in which the applicant receives Federal assistance from the Department of Energy.

5.6 GRANTEE COMMITMENTS

On award of a grant, the grantee will be required to make certain legal commitments through acceptance of numerous provisions in the Phase I grant. The outline that follows is illustrative of the provisions that will be included in the Phase I grant. This is not a complete list of provisions to be included nor does it contain specific wording of these clauses.

a. **Standards of Work**. Work performed under the grant must conform to high professional standards.

b. **Inspection**. Work performed under the grant is subject to Government inspection and evaluation at all reasonable times.

c. **Examination of Records**. The U.S. Comptroller General (or a duly authorized representative) shall have the right to any directly pertinent records of the grantee involving transactions related to this grant.

d. **Default**. The government may terminate the grant if the grantee materially fails to comply with the terms and conditions of award.

e. **Termination**. The grant may be terminated in whole or in part at any time by the government, with consent of the grantee; or by the grantee, upon written notification to DOE setting forth the reasons.

f. **Disputes**. Any dispute concerning the grant which cannot be resolved by agreement shall be decided by the Grants Specialist with right of appeal.

g. **Grant Work Hours**. The grantee may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (e.g., overtime pay).

h. **Equal Opportunity**. The grantee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. **Affirmative Action for Veterans**. The grantee will not discriminate against any employee or applicant for employment because he or she is a disabled veteran.

j. **Affirmative Action for Handicapped**. The grantee will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. **Officials Not to Benefit**. No government official shall benefit personally from the grant.

l. **Covenant Against Contingent Fees**. No person or agency has been employed to solicit or secure the grant upon an understanding for compensation except bona fide employees or commercial agencies maintained by the grantee for the purpose of securing business.

m. **Gratuities**. The Government may terminate the grant if any gratuity has been offered to any representative of the Government to secure the grant.

n. **Patent Infringement**. The grantee shall report each notice or claim of patent infringement based on the performance of the grant.

5.7 ADDITIONAL INFORMATION

a. This solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR or STTR award, the terms of the award shall control.

b. Before issuing an SBIR or STTR award, the Government may request the applicant to submit certain organizational, management, personnel, and financial information to assure responsibility of the applicant.

c. Unsolicited grant applications will not be accepted under SBIR/STTR programs in either Phase I or Phase II.

d. If a written request for a debriefing is received by the SBIR/STTR Program Manager **within 30 days after the announcement of the final selections,** the small business will be provided with written information pertinent to DOE's evaluation of the grant application. The identity of reviewers or their affiliation will not be disclosed. Specific scores will not be provided.

e. Any submission incorporating data affecting the national security will not be accepted for evaluation.

6. SUBMISSION OF GRANT APPLICATIONS

6.1 NUMBER OF COPIES

The following must be submitted:

- Original application, which includes:
  - a. Cover Sheet (Appendix A),
  - b. Project Summary (Appendix B),
  - c. Main Text as required in Section 3.3,
  - d. Budget Form (Appendix C),

Note: Signatures are required on the Cover Page and the Budget Form.

- 6 additional copies of the application
- 4 additional copies of the Project Summary
- (Appendix B)
- 1 completed Checklist and Statistical
- Information form (Appendix D)
- 1 addendum, "Documentation of Multiple
- Phase II Awards" (if appropriate)
- 1 Level of Effort Worksheet (reverse side of App. D)

Grant applications must be addressed to:
SBIR/STTR PROGRAM MANAGER (SC-32)
U.S. DEPARTMENT OF ENERGY
19901 GERMANTOWN ROAD
GERMANTOWN, MD 20874-1290

Phase I grant applications hand carried by the applicant may be delivered to the above mentioned address only. Due to increased and changing building security procedures, applicants who plan to hand carry their grant applications to the DOE Germantown address are advised to call (301) 903-1414 several days ahead to obtain specific delivery instructions. Applications **will not** be accepted by the Department at its Independence Avenue SW, Washington, D.C. address. If a grant application acknowledgement letter with the grant application number endorsed on it is not received from DOE within three weeks following the closing date of this solicitation, the applicant should telephone the SBIR/STTR Program Office promptly at (301) 903-1414.

6.2 DEADLINE FOR RECEIPT OF GRANT APPLICATIONS

a. **Any grant application received after 5:00 p.m. EST on Tuesday, January 15, 2002, will be considered late unless it was sent by the U.S. Postal Service's registered or certified mail not later than January 8, 2002.** Since the postmark will be the evidence on which the decision is made, it is incumbent on applicants to assure themselves that the postmark is clear and easily legible; hand cancellation is suggested. **Late grant applications will not be eligible for award and will be declined without a review**. Experience has shown that Two-Day Priority Mail and overnight express couriers do not always meet the deadline. Please plan accordingly. The Department takes no responsibility for applications arriving after 5:00 p.m. EST, January 15, 2002. Applications submitted by telefax or e-mail **will not** be accepted.

b. Modifications to grant applications that are intended to be incorporated into the review/award process will be accepted **if received by the deadline,** and are clearly marked as modifications.

c. Grant applications may be withdrawn by a written notice received at any time prior to award. The DOE will retain one file copy.

6.3 PHYSICAL PACKAGING

Do not use special bindings or covers. This will delay processing of your application while they are removed. Staple the pages in the upper left hand corner of each grant application. Secure packaging is mandatory. The Department will not be responsible for the processing of grant applications damaged in transit.

7. SCIENTIFIC AND TECHNICAL INFORMATION SOURCES

Applicants may want to obtain scientific and technical information related to their proposed effort as background or for other purposes. Sources of this information are listed in the bibliographies of each technical topic.

7.1 NATIONAL TECHNICAL INFORMATION SERVICE

Reports resulting from Federal research and those received from exchange agreements with foreign countries and international agencies are available to the public in both paper copy and microfiche through the National Technical Information Service (NTIS). They may be ordered electronically from http://www.ntis.gov or by telephone for dispatch through regular mail for a nominal fee from:

NTIS
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
1 (800) 553-6847

Rush service (dispatched within 24 hours by an overnight courier) is available for an additional cost.

Alternatively, microfiche of unclassified, unlimited DOE reports is available for use by the public free of charge in Government Printing Office depository collections. More than 1,400 public, college, and university libraries around the country are designated as U.S. Depository Libraries. Check with a local public library. Most libraries participate in an inter-library loan service whereby one may request copies of an unavailable publication from another library.

7.2 DOE OFFICE OF SCIENTIFIC AND TECHNICAL INFORMATION

The Office of Scientific and Technical Information (OSTI) coordinates the Department of Energy's Technical Information Management Program. OSTI collects, preserves, and disseminates scientific and technical information resulting from DOE's research and development activities. It makes worldwide scientific and technical information available to DOE's customers and the general public. Potential SBIR applicants can obtain information from the following OSTI sources:

(1) DOE Information Bridge, a searchable web-based tool with 30,000 full-text DOE R&D reports (see Web site http://www.osti.gov/bridge). Note: Current DOE contractors and grantees wishing to obtain access should call OSTI at 423-576-8401 or 423-576-0487, or E-mail informationbridge@adonis.osti.gov.

(2) R&D Project Summaries, a web-based system describing each of 15,000 DOE R&D projects (see Web site http://www.osti.gov/rdprojects).

(3) EnergyFiles Virtual Library Environment, a digital library of over 400 energy-related databases and other information resources (see Web site http://www.osti.gov/EnergyFiles).

(4) PubSCIENCE, allows the user to search abstracts and citations of multiple publishers at no cost. Once the user has found an interesting abstract, a hyperlink provides access to the publisher's server to obtain the full text article. The article will come up immediately if the user or his/her organization has a subscription to the journal. If the user lacks such a subscription, access to the full text can be obtained by pay per view, by special arrangement with the publisher, library access or through commercial providers.
PubSCIENCE is available for public use through the Government Printing Office's "GPO ACCESS". It can be accessed at http://pubsci.osti.gov or http://www.access.gpo.gov/su.docs.

7.3 OTHER SOURCES

Literature and database searches for abstracts, publications, patents, lists of Federal research in progress (the FEDRIP database), and names of potential consultants in the specific research area can be obtained at good technical libraries (especially those of universities), and from some state organizations.

<u>Please note:</u>* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.

TECHNICAL TOPICS

<u>Please note:</u> (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.

PROGRAM AREA OVERVIEW - FOSSIL ENERGY

http://www.fe.doe.gov

Fossil energy plays a key role in our nation's prosperity, and it is important that we secure an adequate energy supply from our coal, natural gas, and oil resources. However, national complacency, derived from low-cost imported oil, has allowed petroleum imports to increase to alarming levels in the last two decades. We need not go far back in history to find out how uncertainty in petroleum supply can affect our nation's economic growth. Nonetheless, our near term power generation, heating, and transportation needs still require the utilization of these hydrocarbon-based fuels. As the economy expands, demand for hydrocarbons will increase accordingly. Therefore, the Office of Fossil Energy seeks to develop advanced fossil energy technologies that are environmentally sound and economically competitive.

Technological innovation is required to take advantage of the United States' large supply of coal and natural gas reserves. Coal's major drawback is that it contains sulfur, nitrogen, and trace heavy metals, precursors of pollutants that could have deleterious effects on the environment. Natural gas is also produced with a wide variety of pollutant-forming compounds, which preclude some applications such as fuel cells and advanced gas turbines. For both coal and natural gas, further improvements are needed to develop advanced, low cost, high-efficiency processes for the production of clean energy. Advanced technology development in materials utilization and recovery will be needed for these products - as well as innovations in sensors, electronics, and controls - to be commercially competitive.

Improvements are also needed in our ability to recover both oil and natural gas. About two-thirds of our national petroleum reserve is "unrecoverable"; i.e., it cannot be extracted economically by conventional means. This unused resource could play a major role in supplementing the national petroleum supply if efficient approaches were developed for improved extraction. Natural gas production and utilization could also be increased through improved characterization of reserves and better infrastructure.

The purpose of this solicitation is to seek the participation of small businesses in addressing problems related to utilization of coal and natural gas to produce power, and to the recovery of oil and natural gas.

1. MEASUREMENT AND TECHNOLOGY FOR GASIFIERS

To sustain our economic growth, we need to utilize our most abundant fossil energy resources, coal and natural gas, efficiently and environmentally safe. The Department of Energy (DOE) is supporting the development of advanced technology power plants that offer higher efficiency, lower emissions, and reduced capital and operating costs. The "Vision 21" concept is a new approach to the production of energy from fossil fuels in the 21st century. It will integrate advanced concepts for high-efficiency power generation and pollution control into a class of fuel-flexible facilities capable of operating with near zero environmental emissions. The approach includes a variety of configurations to meet differing market needs, including both distributed and central generation of power. The development and optimum performance of advanced coal gasifiers will be critical to the success of this program. This topic seeks to develop key support technologies and measurement techniques for these gasifiers. **Grant applications are sought only in the following subtopics:**

a. Removal of Mercury and Other Trace Contaminates in Gasifiers - Unlike pure chemical fuels like hydrogen or methane, coal and coal-biomass mixtures have trace amounts of non-fuel contaminates that are transferred to the gaseous phase when the fuel is gasified. These contaminants and their products then have the undesirable potential to be released into the environment if the gasifier product gas is burned or to pose problems for further downstream chemical processing of the gas. Examples of these contaminates are mercury, cadmium, arsenic, ammonia, selenium, sulfur, chlorine, hydrogen chloride, and hydrogen fluoride. While there are technologies available that can effectively remove these contaminates, these techniques are typically best used at relatively low temperatures and mild pressures, and can be costly to implement. Grant applications are sought to remove the trace contaminants stemming from the gasification of coal and coal-biomass mixtures at temperatures of at least 500°F and at pressures in the range of 200 to 1000 psi. The level of contaminant removal should be similar to or better than the levels achieved with conventional technologies that operate at less severe conditions. While the removal of only one contaminant - mercury being the highest priority - would be of interest, priority will be given to approaches for the

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simultaneous removal of more than one contaminant.

b. Feedstock Monitoring in Gasifiers - Grant applications are sought for the development of advanced on-line instrumentation to measure the solid mass flow entering the gasifier as well as other important feedstock characteristics such as heat content, organic content, total mineral content, and ash content. Of particular interest are approaches that can continuously and simultaneously measure more than one of the following feedstock parameters: feed rate; heating value; percent water content; concentrations of ash, sulfur, and nitrogen; and trace elemental contaminants such as mercury, arsenic, cadmium, or lead. Potential gasifier feed streams could be either dry or slurry, and the fuel feedstocks include all ranks of coal as well as various biomass materials.

c. Temperature Measurement in Gasifiers - Grant applications are sought to develop robust temperature sensing techniques, instrumentation, or materials suitable for use in high temperature sensing applications. These techniques or materials need to be capable of accurately measuring temperatures in the range 500-2600°F at pressures from 400 to 1000 pounds per square inch. The harsh conditions inside the gasifer (which include a dirty, reducing, corrosive, and high-pressure atmosphere) are a major barrier to accurate temperature measurement. The environment in which the sensor must operate contains granular carbonaceous material, sticky and/or molten ash, and gas containing significant quantities of methane, water vapor, carbon monoxide, hydrogen, and low concentrations of alkali metals, hydrogen sulfide, hydrogen chloride, and ammonia. Proposed approaches should demonstrate the ability to withstand the relatively aggressive operating conditions found within a coal gasifier for one year of continuous operation.

d. Monitoring Particulates and Corrosion in Gasifiers - Grant applications are sought to develop a low level (0-10 ppm) particulate sensor to monitor the performance and/or failure of candle filters, used in gasification to remove particulates prior to delivering the gas stream to the turbine. Sensors that can determine whether or not the particulate concentration exceeds a specified set point (e.g., above or below 10 ppm) are of interest; however, sensors that can determine the particulate concentration are even more desirable. The sensor must be able to operate at temperatures in the range of 500-1000°F and at pressures on the order of 400 psi for up to one year. Although the temperature is not expected to vary greatly, the pressure will fluctuate, as the filters are routinely cleaned by reversing the gas flow and pulsing the filters.

Grant applications are also sought to monitor corrosion or determine the alkali concentration on-line within the gasifier. As alternative feedstocks are utilized, the concentration of alkali may increase and subsequently require control. Because alkali is thought to be generated in the gasifier at temperatures ranging from 800-2600°F, the measurement technique would have to be robust enough to withstand temperatures in this range, as well as other harsh conditions.

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2. SENSORS AND CONTROLS FOR ADVANCED POWER SYSTEMS

The utilization of sensors and advanced controls can provide the power industry with increased operational efficiency, reduced emissions, and lower operating costs. Concurrent with developments in power generation technology (advanced combustion, gasification, turbines, and fuel cells) advancements in robust sensing and control algorithms can accelerate the time to full-scale commercial implementation. However, the harsh conditions, created when converting fossil fuel to energy, present a barrier to making many of the desired measurements. The harsh conditions include high temperatures (1000-2000?C), elevated pressures (400-1000 psi), pressure oscillations, corrosive environments (reducing conditions, gaseous alkali), surface coating or fouling, and high particulate loading. Other factors (accuracy, reliability, longevity, calibration or validation, and cost) also increase the risk for developing commercially viable sensors and controls. **Grant applications are sought only in the following subtopics:**

a. On-Line Flow Quantification or Flow Control Via Fast Actuation - The optimization and control of the solid-fuel/air ratio are important for combustion or gasification processes. However, optimized control cannot be achieved without more rapid online detection and ensuing actuation methods to control the fuel and airflow. Grant applications are sought to develop techniques and designs for the rapid measurement and/or control of the solid fuel flow to individual burners and nozzles. Technique development and designs should focus on coal as the solid fuel of interest.

b. Emission Sensors for Use in Harsh Conditions - Minimizing and controlling emissions are critical functions in power generation systems. Emission monitoring is currently conducted in the stack or at the outlet of a system. Because of the lag time associated with stack measurements, these measurements are not used for closed loop control of the combustion process to minimize emissions. For closed loop control, novel sensors or sensing materials will be needed for combustion zone monitoring of emissions. Therefore, grant applications are sought to develop robust NO_x sensors that can tolerate the harsh conditions in the combustion region. Proposed approaches may address one or more specific applications for the NO_x measurement (i.e. turbine, boiler, SCR system); the key is the development of a robust sensor.

Grant applications are also sought for the accurate measurement of total and speciated mercury on-line, suitable for toxic release reporting. Accuracy and sensitivity of the measurement technique to low ppm levels of mercury in flue or exhaust gases will be a key consideration. Although not an initial requirement, proposed on-line approaches that also are highly robust would be of particular interest.

c. Advanced Control Algorithms to Facilitate the Integration and Operation of a Vision 21 Modular System - The Vision 21 Program is aimed at providing technologies for ultra-clean fossil fuel-based energy production with 60-75 percent efficiencies and near zero emissions. The program takes a modular approach to system development not only to generate power, but also to co-produce clean fuels, chemicals, steam and other useful products. In order to achieve ultra-high efficiency and environmental performance, the individual systems must operate at optimum conditions and in an integrated fashion. These challenging goals will require a multi-level, highly integrated, advanced control system. With modular, but interdependent components, the initial approach for control is an umbrella master/advisory system that integrates the controls for modular components through standardized communication. Grant applications are being sought for modular systems controls that incorporate smart feedback or feed-forward algorithms, utilizing neural networks and predictive models. Proposed approaches must include provisions for validating the models or algorithms.

d. Advanced Sensors to Improve Performance of Advanced Turbines - In order to sustain high performance in the operation of advanced turbine systems, new sensors are needed to improve reliability and control. Grant applications are sought to develop non-intrusive or embedded sensors that monitor component degradation and combustion instabilities. For component degradation, such as blade integrity, sensors are needed to monitor the failure of the thermal barrier coating and corrosion of the metal components. For combustion instabilities, sensors with millisecond response times are needed to monitor pressure oscillations or differential pressure. Of particular interest are approaches that include the development of smart sensing materials. Proposed sensors should be applicable to micro-turbines as well as large scale turbines; however, for micro-turbines in distributed power generation applications, consideration should be given to the remote data transmission capabilities of the instrumentation, used to carry out performance monitoring and system control from distant locations. Lastly, proposed approaches should compliment DOE's ongoing sensor development efforts (including flame ionization, flame condition, and flashback sensors) to improve turbine reliability and control.

Proposed materials and sensors must be capable of withstanding prolonged exposure to extreme conditions - temperatures within the turbine can be extremely high (2000?C) and are the primary barrier to most monitoring techniques. Typical operating pressures for a turbine are around 300 psi. For the purpose of sensor development, assume that the operating conditions for micro-turbines are similar to those for large scale turbines.

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3. MATERIALS RESEARCH FOR FOSSIL ENERGY APPLICATIONS

The objective of the Fossil Energy Materials Program is to conduct research and development on materials for longer-term fossil energy applications as well as for generic needs of various fossil fuel technologies. The focus is on research leading to a scientific understanding of high-performance materials compatible with hostile fossil environments. The aim of exploratory research is to generate new materials, ideas and concepts which have the potential to significantly improve the performance or cost of existing fossil systems or enable the development of new systems and capabilities. Consequently, developing improved materials for high-temperature, high-pressure heat exchangers, hot gas filtration to remove particulate matter formed during coal combustion and coal gasification, high-temperature fuel cells, and advanced turbine systems (ATS) constitute major objectives of the program. **Grant applications are sought only in the following subtopics:**

a. Hydrogen Separation Membranes - Ceramic membranes offer significant advantages over other membranes; they show greater stability under the IGCC (Integrated Gasification Combined Cycle) operating conditions and are likely to have a higher resistance to attack by the flue gas. In addition, the separation of streams of hydrogen and carbon dioxide in IGCC by ceramic membrane technology is more efficient than other separation technologies. Two types of ceramic membranes are being investigated for the recovery of hydrogen from coal gasification streams: porous membranes and dense membranes. These membrane types differ significantly in their microstructures, and, therefore, gas separation takes place by entirely different hydrogen diffusion mechanisms as described below. Grant applications are sought to further the development of either or both types of these ceramic membranes for commercial hydrogen production. Proposed approaches must demonstrate that the hydrogen can be produced in large quantities and at high purity; therefore, both the permeation properties and the selectivity of the membranes must be well characterized and understood.

In porous membranes, hydrogen is transported through the pores as molecules and the process occurs readily. The separation membrane is usually made from silica and/or alumina supported by a highly porous ceramic layer. Porous membranes are being designed to operate at temperatures in the region 500-600?C to be compatible with IGCC integration. Currently, the maximum operating temperature for these membranes is 300?C, although even at this temperature, there are concerns over the stability in H_2O-containing atmospheres.

In dense membranes, hydrogen is transported in the solid phase as hydrogen ions (protons). The materials of interest for dense membranes are those which show high protonic conductivity, such as $SrCeO_3$- and $BaCeO_3$-. Transport in the solid phase requires more thermal energy than gas phase transport and hydrogen fluxes comparable to those obtained from porous membranes are only achievable at much higher temperatures, typically around 900?C. However, dense membranes offer a significant advantage - in principle, they can produce very high purity hydrogen because only hydrogen is transported through the membrane.

b. Turbine Coatings Development - Protective coatings play a key role in permitting the higher-temperature operation of advanced gas turbines and in extending the service life of these components. These coatings are broadly categorized as thermal barrier coatings (TBCs) and environmental barrier coatings (EBCs), depending on their primary function. In the past, the designs for these coatings, especially TBCs for single crystal (SX) turbine blades, were developed through a phenomenological approach. However, today, emphasis is on prime-reliant design (i.e., providing the designer with safe performance criteria) based on sound mechanistic knowledge of gas-solid interactions at high temperatures, and of the way in which these interactions influence the processes involved in degradation during service. Grant applications are sought for high-temperature protective coatings for gas turbines, along with a coherent strategy for their development. The aim is to identify the physically attainable limits and to push the operating envelope to that point through prime reliant design. Proposed approaches for the coatings should demonstrate low thermal conductivity, adhesion, and survivability under operating conditions.

Areas of interest include coatings for turbines based on both SX alloys and ceramics. For metallic substrates, separate coating layers may be required for the environmental and thermal barrier functions, whereas for ceramics, it may be possible to fulfill both roles in a single coating layer. Also of interest are manufacturing/coating processes that are airfoil-specific - e.g., coatings for vanes may be different than those for blades (different property/thickness requirements lead to different coating processes, etc.).

c. Innovative Sealing Concepts for Intermediate Temperature Planar Solid-Oxide Fuel Cell Systems - Many planar solid-oxide fuel cell (SOFC) design concepts utilize gas seals at the edges or within the gas ports/manifolds to prevent mixing of the fuel and oxidant streams, as well as to maintain separation from the surrounding atmosphere. Effective long term, hermetic sealing at 700-850?C operating temperatures in the SOFC reducing and oxidizing environments is a limiting factor in the reliability of SOFC power systems. The designs are challenged further by the need to maintain hermetic sealing through operational transients that include material thermal expansion and contraction differences during start-up and shutdown periods and electrical load variations. Thermal stresses at the interfaces between different cell and stack materials tend to cause mechanical degradation. This is exacerbated by the fact that the tensile strength of SOFC materials is generally 20 percent of the compressive strength. Therefore, effective hermetic sealing concepts need to provide a degree of compliance to accommodate cell movement while minimizing structural loading to limit mechanical stresses on delicate cell components.

Grant applications are sought for innovative hermetic sealing materials and design concepts (e.g., compliant compressive seals, active seals, brazing) for planar SOFCs that operate in the above temperature range. Proposed approaches should combine analysis and testing to evaluate the practical limit of the sealing concept and demonstrate a potential service life of more than 40,000 hours for stationary systems, or at least 5,000 hours and 3,000 thermal cycles for transportation systems. Of particular interest is a determination of the structural load applied to cell components as a function of both temperature and temperature rate of change. Also of interest is a determination of cell surface condition requirements for various seal concepts, needed to support economic trade-off studies between seal material costs and cell surface machining costs. The ultimate objective is the development of an economically practical combination of both cell surface conditions and hermetic seal material/design that will achieve long life, gas tight sealing in the oxidizing and reducing environments of solid-oxide fuel cells.

d. Contaminant Resistant Anodes and Reforming Catalysts for Intermediate Temperature Solid Oxide Fuel Cell Power Systems - Achieving the DOE Solid State Energy Conversion Alliance (SECA) goal for fuel-flexibility will require the development of solid-oxide fuel cells (SOFC) power systems that can withstand the carbon and sulfur contaminants that exist in a variety of hydrocarbon fuels. In these SOFC systems, catalysts are used to reform the hydrocarbon fuels (e.g., diesel, gasoline, and natural gas) into a hydrogen rich synthesis gas that is supplied as fuel to the anodes. However, both the reforming catalysts and the fuel cell anodes experience performance and life limiting degradation due to carbon deposition and sulfur poisoning. Current methods to ameliorate these problems are difficult to implement. For example, carbon deposition can be inhibited by maintaining excess water vapor, which requires relatively large and costly equipment to preheat inlet water and then reclaim that water from the fuel cell exhaust (and/or replenish the water via an external source). Likewise, costly heat exchangers and adsorbent beds are currently employed to remove sulfur before the fuel reforming equipment (in order to protect the reformer catalyst) and/or after reforming (to protect the fuel cell anode).

Grant applications are sought to develop materials for the production of SOFC anodes or reforming catalysts that tolerate both carbon deposition (at reduced water concentrations) and high sulfur content (i.e., tolerant of >50 ppmv sulfur without prior desulfurization) from complex hydrocarbon fuels, without significant additions to the volume, weight, and costs of these systems. Selected materials must be thermally and chemically compatible with SOFC power systems and materials, and must sustain operating performance >40,000 hours for stationary applications and >5,000 hours and 3,000 thermal cycles for transportation systems. Lifetime effects (phase stability, thermal expansion compatibility, conductivity aging, and electrode sintering) must be addressed and characterized to the extent possible.

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4. OIL AND GAS TECHNOLOGIES

The Department of Energy (DOE) seeks innovative methods and concepts that will contribute to more efficient and economic processes for the recovery and utilization of oil and natural gas. Much of the known reserves of oil and gas discovered in the United States cannot be recovered by conventional techniques. The utilization of fossil fuels can be enhanced by the commercial production of pure fuels from natural gas. Accordingly, characterization, production, and utilization, as well as development of infrastructure, are important to the success of the program. **Grant applications are sought only in the following subtopics:**

a. Heavy Oil Recovery Using Cold Production or Cold Production with Sand - Cold Production or Cold Production with Sand are specialized methods used to aggressively recover and produce heavy oil. These methods produce large volumes of sand and result in cavities or wormholes in the reservoir. The yields of oil, typically produced as foamy oil or as a thick continuous foam, are usually greater than that predicted by current modeling methods; the productivity of heavy oil wells that undergo cold production may exceed radial Darcy flow predictions by factor of 10. However, these methods are costly and difficult to put into practice. Grant applications are sought to develop methods to improve Cold Production or Cold Production with Sand. Proposed approaches should include research to explain the abnormally high recovery rates of these methods. Thermal methods that use heat to lower the viscosity, including steam injection or in-situ combustion, are not of interest and will be declined.

b. Natural Gas Downstream Processing & Utilization - Over the past decade, the DOE Gas Processing Program has evolved in support of our national goal to expand the development and utilization of our abundant domestic natural gas resources. The use of natural gas offers environmental benefits over other conventional energy sources and helps to offset increasing oil imports. However, some natural gas resources (e.g., low quality on-shore or off-shore wells, coalbed methane production, or landfill gas sites) are in remote locations or contain large amounts of nonmethane gases and natural gas liquids which make them uneconomical to market as natural gas. If the nonmethane impurities and natural gas liquids could be removed, the economic and energy efficiency impacts would be significant. Grant applications are sought to develop small-scale facilities for raising low-quality raw natural gas to pipeline quality by removing nitrogen, carbon dioxide, water, hydrogen sulfide, and natural gas liquids. With respect to the removal of hydrogen sulfide from natural gas, the techniques sought must also encompass its subsequent or direct conversion to elemental sulfur or other environmentally benign products. Approaches that have crosscutting applications in coal and other fuel related areas (where feed, combustion, or waste streams require removal of impurities or the need to concentrate specific components) are of interest. These technology approaches may include membranes, absorption/adsorption, and/or hybrid combination of these technologies. In addition, in order to show market potential, teaming with industry for possible field-testing and demonstration of these techniques is required.

c. Deep Gas Drilling - In a recent National Petroleum Council gas study, deep formations were found to be the leading frontier for gas resource development. Without additional improvements in drilling technology, the development of this deep gas resource will be delayed until gas prices increase significantly. To augment DOE's deep gas drilling program, grant applications are sought to develop: (1) innovative, high-penetration-rate directional drilling systems (complete drill bit and motor systems, such as a directional air hammer, turbine, or other devices with the potential for penetration rates approaching that associated with underbalanced drilling) capable of minimal-vibration drilling to allow the unimpeded operation of downhole electronics associated with "smart" systems; (2) smart nanotechnology-based systems for use in high temperature downhole monitoring and/or control applications, capable of operating in excess of 200?C, preferably without active cooling (although active cooling would be considered if a complete system, such as a measurement-while-drilling (MWD) package based on nanotechnology, could be demonstrated to be potentially feasible and cost effective); or (3) high performance (high pressure, high temperature) sensors, suitable for use in logging-while-drilling (LWD) systems and capable of demonstrating a significant increase in performance compared to current systems (such as improved gamma ray detectors).

d. Natural Gas Infrastructure Reliability - Maintaining the integrity and reliability of the natural gas distribution and transmission systems across the United States is essential to ensure the availability of clean, affordable energy for our homes, businesses, and industries. Natural gas consumption in the U.S. is projected to reach or exceed 35 trillion cubic feet (TCF) per year by 2020, increasing from 22 TCF per year in 1997, and this increase will require maintaining much of the existing natural gas infrastructure and expanding on it. DOE's National Energy Technology Laboratory (NETL), through the Strategic Center for Natural Gas (SCNG), recently initiated a new program involving infrastructure reliability. The purpose of the Infrastructure Reliability for Natural Gas Program is to provide research and technology development to maintain and enhance the integrity and reliability of the Nation's gas transmission and distribution network. Grant applications are sought to develop: (1) advanced automation technologies, including sensors, for improved automated data acquisition, system monitoring, and control techniques between the field and control centers; or (2) improved technologies or tools (suitable for small openings - i.e., "keyhole" technologies) for internal repair of damaged pipe. Applicants are encouraged to review the document, "Pathways for Enhanced Integrity, Reliability and Deliverability" (available on the NETL Website at http://www.netl.doe.gov/scng/publications/naturalg.pdf), which summarizes a NETL-sponsored roadmapping session to identify priority research needs for the natural gas pipeline infrastructure.

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PROGRAM AREA OVERVIEW - BASIC ENERGY SCIENCES

http://www.er.doe.gov/production/bes

The Basic Energy Sciences (BES) program supports fundamental research in the natural sciences leading to new and improved energy technologies. The program's purpose is to create new scientific knowledge by supporting basic, peer-reviewed research in areas of materials sciences, chemical sciences, geosciences, plant and microbial biosciences, and engineering sciences that are relevant to energy resources, production, conversion, and efficiency. The results of BES-supported research are routinely published in the open literature.

A key function of the program is to plan, construct, and operate premier national user facilities to serve researchers at universities, national laboratories, and industrial laboratories, thus enabling the acquisition of new knowledge that cannot be obtained in any other way. The scientific facilities include synchrotron radiation light sources, high-flux neutron sources, electron-beam microcharacterization centers, and specialized facilities such as the Combustion Research Facility. These national resources are available free of charge to all researchers based on the quality and importance of proposed nonpropriety experiments.

A major objective of the BES program is to promote the transfer of the results of our basic research to advance and create technologies important to Department of Energy (DOE) missions in areas of energy efficiency, renewable energy resources, improved use of fossil fuels, mitigation of the adverse impacts of energy production and use, and future fusion energy sources. The following set of technical topic s represents one important mechanism by which the BES program augments its system of university and laboratory research programs and integrates basic science, applied research, and development activities within the DOE.

5. ADVANCED FOSSIL FUELS RESEARCH

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from fossil fuels. However, maintaining low-cost energy in the face of growing demand and increasing environmental pressure will require new technologies, which must allow the Nation to use its indigenous resources more wisely, cleanly, and efficiently. These resources include both coal, the Nation's most abundant and lowest cost resource, as well as inherently clean natural gas. One of the key recommendations of the National Energy Policy is to improve energy efficiency through the implementation of innovative technology. **Grant applications are sought only in the following subtopics:**

a. Methane Conversion Processes - The very large reserves of conventional natural gas (approximately 13,000 trillion cubic feet) could serve as a feedstock for the production of fuels and chemicals well into the 21st century. However, a substantial portion of these reserves are not located close to major gas markets and considerable investment would be required to move the gas to market. Following the oil crisis of the 1970's, world wide research and development efforts have sought commercially viable processes for converting methane, the major constituent of natural gas, to more valuable and easily transportable chemicals and fuels. Such processes might also allow the large deposits of natural gas hydrates to be tapped.

Existing processes for converting methane to methanol and higher hydrocarbons are indirect since they require the initial formation of synthesis gases. Direct methane conversion has the potential of being more energy efficient by bypassing the energy intensive step of synthesis gas formation. However, high selectivity at a reasonable conversion per pass has been difficult to achieve. Grant applications are sought for the catalytic conversion of methane to more useful chemicals and fuels. Areas of interest include: (1) steam and carbon dioxide reforming or partial oxidation of methane to carbon monoxide and hydrogen, followed by Fischer-Tropsch chemistry, (2) the direct oxidation of methane to methanol and formaldehyde, (3) oxidative coupling of methane to ethylene, and (4) direct conversion to aromatics and hydrogen in the absence of oxygen.

b. Carbon Sequestration/Conversion - Carbon sequestration is a relatively new approach to the stabilization of greenhouse gas concentration (i.e., new compared to the other two pathways - improving the efficiency of energy use and reducing the carbon content of fuels). Current approaches include the conversion of carbon dioxide to benign, stable compounds for long-term storage or to value added products for reuse. Grant applications are sought to develop practical methods to: (1) grossly accelerate the natural bioconversion of carbon dioxide to methane in geologic reservoirs by employing methanogen microorganisms as catalysts, as well as other geochemical reactants, (2) apply similar processes to the capture of carbon dioxide at large point sources, and (3) efficiently employ microorganisms and/or biomimetic catalysts to convert carbon dioxide in flue gas to intermediates that can be subsequently reacted to calcium/magnesium carbonates for terminal sequestration.

c. Solid Oxide Fuel Cells - The development of fuel cells for use in power generation, while highly efficient and nearly pollution free, has faced many challenges. One major hurdle is to reduce the cost of fuel cell power plants to levels that would allow deep penetration into the stationary, transportation, and portable markets. The Solid Oxide Fuel Cell (SOFC), which operates at high temperatures (700 - 1000^{o}C) and utilizes ceramic electrolytes, shows promise for various applications. Unlike lower temperature fuel cells that

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require relatively pure hydrogen (e.g., <10 ppm CO) as fuel, the high operating temperature of SOFCs allows hydrogen with significant amounts of CO, as well as higher hydrocarbons, to be used directly as fuels. However, the high operating temperature also limits the selection of materials that can be used in the highly reducing (anode) and highly oxidizing (cathode) environments in the fuel cell stack. Grant applications are sought to drive down SOFC costs by developing low temperature ($<700^oC$) electrolytes, electrocatalysts for high-power-density direct electrochemical oxidation of higher hydrocarbons, and electrocatalysts for high-power-density electrochemical reduction of oxygen. Grant applications are also sought to develop new processes that may help lower SOFC costs, such as innovative concepts in balance of plant design and the coproduction of fuels and electricity.

d. Improvement of Coal Liquefaction Process - Although technology for the direct conversion of coal to liquid fuels has undergone significant development over the last 15 years (including advances in product yields, quality, and projected product costs), the resultant economics are still not good enough to encourage commercialization. Grant applications are sought for an improved or unique environmentally acceptable process for the economical production of transportation fuels from coal. Proposed processes should provide yields of 70 percent or more of specification liquid transportation fuels at a cost less than $29/bbl. In addition, emissions from the burning of these fuels (in CO_2 per unit of energy output) must be low enough to rival petroleum based fuels.

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6. CATALYSTS FOR PETROLEUM REFINING AND CHEMICAL SYNTHESIS

Over 80 percent of petroleum refining processes involves catalysis. About 90 percent of chemical manufacturing processes and more than 20 percent of all industrial products in the U.S. employ underlying catalytic steps. Catalysis plays a substantial role in the production of 30 of the top 50 U.S. commodity chemicals. Six more of the remaining 20 are made from raw materials that are produced catalytically. The energy use component in the production of the top 50 chemicals is significant - 5 quadrillion BTUs per year - 3 quadrillion BTSs per year for those with catalytic production routes. It has been estimated that if all the catalytic processes associated with petroleum refining and with manufacture of the top 50 chemicals were raised to their maximum yields, total energy savings would exceed one quadrillion BTUs per year. More efficient chemical production, resulting from improvements to catalytic processes, would also contribute to significantly reduced carbon emissions. This topic seeks to accelerate the catalyst discovery and applications process by identifying catalysts that have higher selectivities, can operate at modest temperatures and pressures, and contribute to a reduction in the number of unit operations, all of which impact overall resource efficiency. **Grant application are sought only in the following subtopics:**

a. Catalysts for Optically Active Fine Chemical Synthesis - Many fine chemicals, used as starting materials for other chemicals (e.g., pharmaceuticals, photographic chemicals, dyes and pigments), have one or more asymmetric carbons or other chiral centers that exhibit desirable optical activity. Asymmetric synthesis, based on catalysis, is the preferred process for producing these fine chemicals because alternative processes (separating optical isomers from unwanted isomers, which are discarded or converted to desired isomers) use too much energy. However, existing asymmetric processes are inefficient. Therefore grant applications are sought to develop new catalysts - heterogeneous, homogeneous, or hybrid - for the asymmetric synthesis of optically active compounds. Reactions of interest include oxidations, reductions, alkylations, isomerizations, and substitutions such as halogen substitutions. Proposed approaches are restricted only by the following: (1) the target synthetic compounds must have commercial application, (2) the target compounds must exhibit optical activity, (3) the catalysts must synthesize only one optically active isomer from starting materials that do not exhibit optical activity, and (4) the catalysts must not be commercially available.

b. Commodity Chemical Synthesis - Oxidation is the most energy intensive of all chemical processes for the production of commodity chemicals and polymers. These commodity chemicals include ethylene and propylene oxide, styrene, phenol and acetone, and nitric acid. More selective oxidation could reduce energy consumption by increasing the yield of desired compounds. Grant applications are sought to develop catalysts and associated processes for the synthesis of olefins, aromatics, and oxygenates, the critical building blocks of these commodity chemicals.

c. Catalysts for Petrochemical Synthesis - The petrochemical "building blocks" (including ethylene, propylene, butane, butene, butadienes, benzene, toluene, and xylenes, and their immediate substituted products such as cumene chemicals) are used as starting materials for the manufacture of all other chemicals. Grant applications are sought for improved processes for the petrochemical synthesis of these building block chemicals (starting from petroleum fractions or natural gas liquids), based on the development of new catalysts. As an example, a catalyst used to synthesize ethylene from natural gas liquids, would be of interest under this subtopic.

d. Refinery Catalysts - Catalysts are used in many refinery operations, including catalytic cracking, hydrotreatment, isomerization, reforming, and alkylation. Grant applications are sought to improve the above processes through the development and use of new or improved catalysts. Catalysts selected for investigation must: (1) have applicability to a U.S. refinery operation, (2) demonstrate energy savings either by saving feedstock or by lowering operating conditions such as temperature and pressure, and (3) not be commercially available. Priority will be given to grant applications that include the participation of a U.S. refiner in the development and application of these catalysts.

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7. BIOPRODUCTS AND BIOENERGY RESEARCH

Energy from sunlight, our abundant natural resource, offers the opportunity to utilize a sustainable source of raw materials -- namely, biomass from our nation's crops, forestry, aquatic, and agricultural wastes -- to power our homes, fuel our vehicles, and create everyday products. The use of biomass to produce BioProducts and BioEnergy (BioP&E) will help strengthen U.S. energy security, protect the environment, reduce greenhouse gases, and revitalize rural America. In conjunction with the Office of Basic Energy Sciences, the Office of Energy Efficiency and Renewable Energy (including the Office of Transportation Technologies, the Office of Industrial Technologies, and the Office of Power Technologies) seek environment friendly technologies that enable bio-based renewable resources to produce home-grown transportation fuels, chemicals, materials or consumer products, and generate clean locally-based power. Grant applications must demonstrate that proposed approaches have the potential to be more economical than currently practiced technologies. **Grant applications are sought only in the following subtopics:**

a. Molecular Recognition Separation Technology - Biomass sources often contain some fraction of inherently valuable chemicals, either in its native state or after some processing. For example, corn oil contains small but very valuable amounts of sterols. The pyrolysis of biomass results in a rich mixture of many valuable chemicals. Currently, the cost efficient separation and purification of these valuable chemicals is preventing the wider use of biomass as a source of these chemicals. Molecular recognition separation technology involves the discovery and design of molecular level structures that uniquely associate with a particular molecule, analogous to the way that enzymes work in nature. This molecular recognition could be based on chemical association, hydrogen or other weaker bond association, or possibly size association. Grant applications are sought for the research and development of molecular recognition technology that can be used to obtain valuable chemicals from biomass. The technology could be built into a membrane or resin system to efficiently remove, and thus purify, a single valuable chemical component from a mixture. Mechanisms must also be available to reverse the association in order to release and thus recover the valuable component.

b. Cetane Additives for Diesel Fuel - For diesel engine fuel, the cetane number measures ignition delay; higher cetane numbers are desirable because there is less time between fuel injection and ignition. In addition, diesel fuels with higher cetane numbers have been shown to have reduced nitrogen oxide (NO_x) emissions. It is believed that the cetane number could be increased by using ignition improvers, or additives. This is common practice in the fuel industry where additive technology has evolved through the laboratory testing of thousands of additives and additive combinations. Furthermore, the best technologies have undergone extensive engine testing and years of field experience. These additives slow the oxidation process, prevent wear, lower friction, disperse contaminants, keep surfaces clean, and prevent corrosion and rust. However, the production of low emission diesel engine fuels may require an evolutionary change in additive technology, since currently used additives contain sulfur, phosphorus, zinc, and other heavy metals that are suspect in reducing catalyst performance and durability. Grant applications are sought to develop and demonstrate cetane additives from renewable sources for diesel blending. These additives must be compatible with the diesel system and with each other. Grant applications should seek to understand both the additive and the additive-materials reactions - in particular, the extent to which the aging (use) of the additive affects additive performance, catalyst efficiency, and engine emissions.

c. Production and Utilization of Low-Cost Sugars of Biomass to Fuels and Chemicals - Plant matter is rich in carbohydrates that can be broken down to C6 and C5 sugars (i.e., glucose and xylose), important intermediate chemicals in the conversion of biomass to biobased products and energy. With further chemical processing, i.e., fermentation, these sugars can serve as feedstocks for higher chemicals and fuels. However, the cost of producing these sugars is a major obstacle to the widespread use of biomass products and energy. If the cost of producing fermentable sugars could be reduced, there would be a tremendous increase in the use of renewable carbon (biomass) in place of fossil carbon for the manufacture of fuel, chemicals, and materials, and this would spur the development of bio-refineries. Grant applications are sought to develop technology that will optimize unit operations for the production of sugar streams from biomass and the fermentation of the varied sugars to fuels and chemicals. Examples of sugar production research include sugar stream separation, sugar recovery methods, detoxification techniques, enzyme development and applications. Examples of sugar utilization research include the development of highly efficient microorganisms capable of fermenting all available biomass sugars in robust environments (such as high sugar concentration and elevated temperatures) and of hydrolysis tolerant microorganisms.

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8. ION BEAM APPLICATIONS FOR MATERIALS INTEGRATION BY LAYER TRANSFER

The ability to produce and manipulate thin films of different materials is vitally important in a number of fields of science and engineering. Micro- and optoelectronics, micro-electro-mechanical devices (MEMs), and lab-on-a-chip are some examples of technologies that require multiple thin layers to produce functional devices. Ion-beam techniques can be used to transfer thin semiconductor films and even fully processed devices from bulk substrates onto alternative host materials. These ion beam techniques allow the circumvention of many limitations (such as lattice mismatch, interdiffusion, and interface chemical reactions) and permits the placement of thin films on nearly any dissimilar material, whether single-crystal, polycrystalline, or amorphous. Newer technologies will require the integration of incompatible or dissimilar materials to an even greater extent.

This topic is focused on the use of ion beams to facilitate the fabrication of a thin layer (less than 10 ?m) of a non-semiconducting material to the surface of another dissimilar material. Specifically, grant applications are sought to use ion beams to produce material changes in a buried region of material in order to facilitate the removal and transfer of a thin layer to a dissimilar substrate. Proposed approaches must stress process innovation; grant applications that address the scale-up of known processes are not of interest and will be declined. Special consideration will be given to grant applications that attempt to elucidate the physical mechanisms responsible for the material transfer process. The grant application also must show how the proposed innovations will result in significant advances over state-of-the-art technologies. **Grant applications are sought only in the following subtopics:**

a. Oxide and Ceramic Materials - Grant applications are sought for the integration of thin films (less than10?m) of oxide and/or ceramic materials onto dissimilar substrates using ion beams. Areas of interest include, but are not limited to, the separation and transfer of ferroelectric materials (or fabrication of freestanding films), buffer layers for epitaxial film growth, and highly-emissive materials. Traditional semiconductor materials, such as Si and GaAs, are specifically excluded as thin film materials (but their use as a substrate material would be of interest).

b. Polymer or Metal Materials, and MEMs Applications- The incorporation of polymer and metal thin films in MEMs greatly increases the device functionality. Therefore, grant applications are sought to integrate polymer or metal thin films with non-similar substrates. Of particular interest are innovative processes that use ion beams to transfer polymer or metal films for use as sensor or actuator elements in MEMs structures.

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9. NEUTRON AND ELECTRON BEAM INSTRUMENTATION

The Department of Energy supports a number of large-scale, national user facilities that provide intense beams of neutrons and electrons for the characterization of materials. **Grant applications are sought only in the following subtopics:**

a. Neutron Facilities ? As a unique and increasingly utilized research tool, neutrons have made invaluable contributions to the physical, chemical, and biological sciences. The Department is committed to enhancing the operation and instrumentation of its present and future neutron science facilities so that their full potential is realized.

Grant applications are sought to develop improved neutron detectors and associated electronics needed for DOE's existing and proposed steady-state and pulsed neutron scattering facilities [References 1-2, 5]. New detectors must represent substantial improvements in one or more of the following parameters: efficiency at short wavelengths, high counting rate capability, high spatial resolution in one or two dimensions, cost per unit area, or adaptability to unique geometries. Detectors for pulsed neutron applications must be able to identify the time of arrival of each neutron. All detectors must have low intrinsic dark count rates and low sensitivity to gamma radiation.

Grant applications are also sought to develop novel or improved neutron optical components for use in neutron scattering instruments [References 2-3, 5]. Such components include, but are not limited to, neutron choppers, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, or neutron polarization devices including ^{3}He polarizing filters. Applications are also sought for novel use of such components in neutron scattering instruments.

b. Electron Beam Microcharacterization Facilities - The Department of Energy supports four collaborative research centers for electron beam microcharacterization of materials. These tools are important in the materials and biological sciences and are used in numerous research projects funded by the Department. Innovative instrumentation developments offer the promise of radically improving the capabilities of electron beam microcharacterization and thereby stimulate new innovations in materials science.
Grant applications are sought to develop stages and holders with new capabilities for *in situ* experiments in the transmission electron microscope. Stages and/or holders must provide for one or more of the following: (i) application of magnetic field up to 5000 Oe in the plane of the specimen, with capability to rotate field orientation in the specimen plane with respect to the sample; (ii) manipulation or measurement of the sample using a 4-probe nanomanipulator, including capability to measure deflection or strain, or capability to apply electric fields or current; and (iii) precision control of specimen temperature (to an accuracy of 10^oC in the range 5-2000K), ambient gas pressure and flow rate (to within several percent for each), and alignment (to an angle accuracy?0.05 degrees on two axes).

Grant applications are also sought to develop electron sources for scanning transmission electron microscopy with brightness on the order 10^9 Amp/cm^2/steradian or higher. Developments in source stability and monochromaticity are also of interest. Current sources are based on tungsten emitters, and it is hoped that higher brightness can be achieved with new materials and designs. Proposed electron sources must be suitably robust for practical applications, have long lifetimes (greater than 6 months), and offer a significant increase in brightness over existing sources.

Grant applications are also sought for systems for automated data collection and processing. Systems should include hardware and platform-independent software for data collection and visualization, including automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and for multi-spectral analysis.

Finally, grant applications are sought for improved x-ray and electron detectors. Electron detectors should be suitable for 200-400kV electrons, and grant applications must focus on (1) serial detectors for scanning and/or (2) parallel imaging devices for conventional or scanning transmission electron microscopy. At least one of the following three aspects must be addressed: high quantum efficiency, high spatial resolution, and high temporal resolution. Proposed detectors must be robust and not susceptible to electron beam damage. X-ray detectors should significantly improve the sensitivity or spectral resolution of x-ray detectors for elemental analysis in electron microscopes, including new detectors and x-ray optic systems.

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10. METAL FORMING

The following subjects associated with metal forming science and technology are consistent with key technologies relevant to the Department of Energy mission. These technologies have been identified as a result of Department of Energy interactions with research focus groups and workshops attended by federal agencies as well and universities and private industry. The bibliography lists some articles providing greater discussion of the areas of emphasis listed in this announcement. **Grant applications are sought only in the following subtopics:**

a. Semi-Solid Forming - Semi-solid forming consists of heating or cooling an alloy into the two-phase, liquid-solid regime where both solid consistency and easy formability, using either casting or forging, are possible. The advantage of semi-solid casting is less shrinkage (voiding) and lower casting temperatures and, thus, less die wear. Forging is accomplished at much lower stresses without losing the "consistency" of a solid. A necessary condition for effective semi-solid forming appears to be a spherical rather than dendritic morphology of the solid phase. This has traditionally been accomplished by electromagnetic stirring, a relatively expensive process that has limited the commercial utilization of semi-solid technology. Grant applications are sought for alternative processing techniques for semi-solid forming that will reduce the cost of the spheroidization step and render the semi-solid process more viable. This opportunity may be particularly viable for aluminum alloys, many of which may be used for automotive applications.

b. Economical Superplastic Forming - Superplasticity is usually described as high tensile ductility of a material (e.g. greater than 600 percent), leading to very favorable forming characteristics. Although superplastically formed parts are now commercially available, particularly in the aerospace industry, widespread application has not occurred - most likely due to the relatively high cost of superplastic forming. These costs are associated with both the thermal and mechanical processing (needed to produce a refined grain size that will lead to superplastic formability) as well as with the relative lengthy time required for the superplastic forming step. Superplastic deformation that leads to high tensile ductilities is usually only observed at low (10^{-4} s^{-1}) strain rates which preclude timely forming and reasonable costs. Grant applications are sought to develop technology for bringing superplastic forming into more widespread use. Areas of research interest include lowering costs by less expensive thermal and mechanical processing, and utilizing alloys that can be formed superplastically at relatively high rates of strain. Basic research is currently being sponsored by the Office of Basic Energy Sciences and other agencies to understand the mechanism of high rate forming, and it is believed that commercial utilization is now more achievable.

c. Other Forming Processes - Alternative processes may also be candidates to replace conventional metal forming practices. Grant applications are sought to develop novel metal forming processes in addition to semi-solid and superplastic forming. These can include a wide range of technologies that lead to improved metal forming.

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11. NOVEL APPROACHES TO THIN-FILM SOLAR CELLS - FABRICATION, PROCESSING, AND CHARACTERIZATION

This topic provides small businesses with an opportunity to carry out substantially novel research and development on the fabrication, processing, and characterization of thin-film photovoltaic (PV) materials and devices with the objective of solving some key research issues that may enable significant improvement in efficiency and cost reductions. Thin-film PV technologies hold promise for substantial cost advantage versus traditional single-crystal and polycrystalline silicon (Si) solar cells because of lower material use, fewer processing steps, and simpler device processing technologies. Currently, thin-film technologies based on amorphous and microcrystalline Si alloy materials, cadmium telluride (CdTe)/cadmium sulphide (CdS), and ternary and quaternary copper indium selenide (CIGS) are the frontrunners for large-scale production. In addition, polycrystalline thin-film Si provides an exciting new opportunity for the development of efficient, low-cost solar cells. Major technological advances have been made in recent years on these technologies in terms of efficiency, reliability, and materials synthesis and processing. However, the gap between the small-area cells and large-area devices and modules is still very large. Therefore, significant opportunity exists for improving materials and device fabrication and developing innovative processing technologies to close this gap. A common element in all of these thin-film solar cells is the use of high-quality, thin-film, transparent conducting oxides (TCO). The primary issues in each of these technologies have been addressed in a recent workshop on Basic Energy Opportunities in Photovoltaics [see reference 1 following this topic].

Grant applications should represent a significant advance in materials or in processing and characterization that will lead ultimately to high-quality, thin-film PV at costs that are competitive with present-day energy sources. Grant applications will be declined if they are: (1) limited to a minor improvement of a material or process, or (2) limited to data collection or a paper study. **Grant applications are sought only in the following subtopics:**

a. Amorphous, Microcrystalline, and Polycrystalline Si Thin Films - Amorphous-to-microcrystalline-to-polycrystalline Si thin films form a continuum of materials architecture that is of interest for developing high-performance PV devices with many interrelated research issues. Compared to other thin-film technologies, amorphous Si has attained a degree of maturity to be considered commercially viable. Nevertheless, grant applications are sought to develop significant improvements in device performance in terms of efficiency, reliability, and cost-effective fabrication, and processing. Areas of research interest include: (1) understanding and control of Si and alloy film structures ranging from amorphous to microcrystalline to polycrystalline phases and the structural relationship to optical and electrical properties that impacts device performance; (2) understanding the role of hydrogen in structural properties, alloying and doping, and in metastability; and (3) novel material deposition techniques to improve growth rates and material properties.

b. Cadmium Telluride (CdTe) Thin Film - Major progress has been made in recent years on CdTe-based, thin-film solar cells. A number of relatively simple, low-cost methods have been used to fabricate efficient solar cells, and record efficiencies greater than 16 percent have been achieved in small-area devices. However, the efficiency gap between a small-area device and large-area modules is in the range of 8-10 absolute percentage points, and therefore, significant development work needs to be done to close this gap. Grant applications are sought to develop technology to improve the efficiency and performance of CdTe thin film solar cells. Other issues of concern are long-term stability and environmental sensitivity of cadmium. Areas of research interest include understanding the basic nature of polycrystalline films such as microstructure, defects, and impurities; stability of surface and interfaces against interdiffusion; post-deposition treatment and other process variables; and development of optimum front and back contacts.

c. Copper Indium Gallium Diselenide (CIGS) - CIGS is by far the most promising material for thin-film PV devices. Recently, a record efficiency of 18.8 percent was achieved in a small-area device fabricated mostly by a physical vapor deposition technique. In a larger CIGS device (a 3651 cm^2 module), a world-record efficiency of 12.1 percent was achieved by Siemens Solar Industries. In spite of these major advances, many hurdles still need to be overcome. Grant applications are sought to develop technology to achieve optimum CIGS device performance and lower-cost manufacturing. Areas of research interest include: (1) development of a predictive understanding of material and device properties; (2) development of a novel low-cost device fabrication method; (3) real-time material characterization and process control; and (4) identification of a novel heterojunction partner other than CdS.

d. Transparent Conducting Oxides - In the field of thin-film solar cells, transparent conducting oxides (TCO) are commonly used as either a substrate or superstrate. An ideal TCO material not only would have very high electrical conductivity and optical transmission in the solar spectrum but also would be chemically inert and structurally compatible with thin-film PV materials in various processing environments. Typical TCO materials, produced commercially and universally used for PV devices, are SnO_2 (Sb or F), indium tin oxide (ITO), and ZnO (Al). Grant applications are sought to achieve superior performance of thin-film solar cells by developing (1) new and improved TCO materials with n- and p-type conductivity, or (2) better ways of making conventional TCO materials with superior electrical and optical properties.

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12. BATTERY TECHNOLOGY FOR

ELECTRIC AND HYBRID VEHICLES

The commercial use of electric and hybrid electric vehicle technologies has been limited by the performance and excessive costs of power sources and storage devices. In conjunction with the Office of Basic Energy Sciences, the Department of Energy's Advanced Automotive Technologies program is interested in identifying and developing innovative concepts for advanced batteries that will improve the performance, extend the life, and significantly reduce the cost of the vehicles.

Electric vehicles (EV's) require batteries with high energy density; hybrid electric vehicles (HEV's) require batteries that can deliver high power pulses. Both types of batteries must be able to accept high power recharging pulses from regenerative braking. For high enegy density batteries, the cells must provide 200 Watt-hours/kg, 400 Wh/l, 400 W/kg and 800W/l or greater, have a life of 1000 cycles at 80 percent depth of discharge, and have a calendar life of at least 10 years. For high power applications, the cells must provide peak power of 1500 W/kg or greater, have a cycle life of at least 300,000 shallow cycles, and have a calendar life of 15 years. For both types of batteries, materials to be utilized should be plentiful, have low cost (< $10/kg), be environmentally benign, and be easily recycled. Evaluation of the technology with regard to the above criteria should be performed in accordance with applicable U.S. Advanced Battery Consortium test procedures or Society of Automotive Engineers recommended practices [see references that follow].

Proposed approaches must be demonstrated in full cells of at least 0.2 Ampere-hour in size, and grant applications must show how proposed innovations would result in significant advances in performance and cost reduction over state-of-the-art technologies. **Grant applications are sought only in the following subtopics:**

a. Lithium-Ion Battery Cathode Materials with Enhanced Stability for EV and HEVApplications - The instability of conventional lithium-ion cathode materials have been shown to contribute in a significant manner to the performance, calendar life, and abuse tolerance limitations of lithium-ion cells and batteries. Grant applications are sought to develop new cathode materials that offer enhanced performance for lithium-ion batteries in EV or HEV applications. Proposed approaches must demonstrate how the particle morphologies and/or the compositional tailoring at the molecular level will enhance the performance of the novel materials in cathode structures. Nanophase species, either as the active material itself or as a stability-enhancing coating, are of particular interest.

b. Stabilization of Lithium/Sulfur Cell Components and Interfaces - Rechargeable metallic lithium/sulfur batteries are of great interest for transportation applications because of their potential for very high specific energy, low cost, and minimal environmental impact. However, instabilities of cell components and interfaces lead to unwanted cell capacity loss and short cell lifetimes. The fundamental causes of these instabilities are poorly understood. Grant applications are sought to address these problems by one of the following approaches: (1) designing a sulfur electrode that offers high active material utilization and stable electrode capacity at high charge and discharge rates; (2) developing polymer or gel electrolytes that are compatible with both lithium and sulfur and exhibit sufficiently high ionic conductivity to support high-rate cell charge and discharge, or (3) developing and demonstrating a method to avoid lithium dendrite formation or other deleterious electrode morphology changes in a lithium/sulfur cell.

c. Novel Electrochemical Couples for Advanced Batteries with an Emphasis on Polyvalent Intercalation Systems - New electrochemical couples offer the potential to overcome the limitations of current electrochemical systems, and to provide high-specific energy, long-life and low-cost alternatives. Grant applications are sought to develop and demonstrate novel rechargeable couples that meet the criteria given in the introduction to this topic. Rechargeable, intercalation battery couples that incorporate anodic active materials such as aluminum or magnesium are of particular interest because of their potential use in high-performance, non-aqueous batteries for electric and hybrid vehicles. Areas of interest include (1) the synthesis and/or characterization of ionic conducting polymers and gel electrolytes that can transport polyvalent ions; (2) development of electrolytes that are capable of conducting alkaline earth, other divalent cations, and trivalent transition metal ions; and (3) development of cathodes composed of intercalation compounds that allow the rapid diffusion of polyvalent ions.

d. Alternative, Low-Cost Separators for Lithium-Based Rechargeable Batteries - There is a need for low cost, alternative separators for lithium-based rechargeable batteries. Grant applications are sought for separators that can be inexpensively manufactured and easily substituted into current battery systems. Proposed materials must have physical characteristics (e.g. strength, flexibility, etc.) compatible with current manufacturing processes for spiral and prismatic cells. The cost of the separators should be estimated on a $/square meter basis, and the key performance measure for the separator should be the specific conductivity when used in a standard liquid electrolyte, lithium-ion (Li-ion) system. Performance, when used in a

Li-ion cell, must be at least comparable to existing Li-ion technology in terms of power density, expected life, etc., in the temperature ranges to which current systems are exposed. Characteristics that enhance safety, such as "separator shut-down" when the battery is abused, are highly desirable.

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13. SOLID STATE LIGHT EMITTING DIODES FOR GENERAL LIGHTING

This topic provides small businesses with an opportunity to carry out substantially novel research and development on the fabrication, processing, and characterization of solid state light emitting diodes (LEDs) and associated systems suitable for general lighting. Solid state lighting represents a major paradigm shift in the lighting industry, with opportunities for major energy saving and pollution control. Steps for achieving this goal have been defined and include: (1) efficacy improvements at all wavelengths to obtain 200 lumen/Watt white-light sources; (2) cost reduction of LED light sources competitive with traditional light sources; (3) development of a new support infrastructure including powering, fixtures, etc.; and (4) identification of new approaches to lighting enabled by LEDs such as "smart" light sources. These and other issues have been addressed in a recent workshop entitled LED Solid State Lighting sponsored jointly by the Department of Energy (DOE) and the Optoelectronics Industrial Development Association (OIDA) [reference 1].

Grant applications should be submitted for consideration under this topic only if the research represents a significant advance in materials or in processing and characterization that will lead ultimately to high-quality LEDs and or phosphors capable of producing white light. Grant applications will be declined if they are: (1) limited to a minor improvement of a material or process, or (2) limited to data collection or a paper study. **Grant applications are sought only in the following subtopics:**

a. Substrates for Nitride-Based LEDs - The group-III nitride-based semiconductors have recently emerged as the leading material for white-light solid state lighting sources. The aluminum gallium indium nitride (AlGaInN) alloy system forms a continuous and direct bandgap semiconductor alloy spanning ultraviolet to blue/green/yellow wavelengths. Currently, there are no commercially available native substrates such as gallium nitride (GaN) or aluminum nitride (AlN) for these nitride-based LEDs. Instead, materials such as sapphire ($A_{l2}O_3$), silicon (Si) and silicon carbide (SiC) are used as the substrates on which the nitride-based LED are grown. Because of lattice constant mismatch conditions between these substrates and the nitride-based LED, defects, dislocations, and other undesirable effects are produced, leading to poor LED performance. Grant applications are sought to develop methods for growing large (greater than 2 inches), defect free, native (bulk) substrates such as GaN and or AlN, leading to high power and high quality LEDs. While preliminary results show some success in producing bulk GaN [2, 3] and AlN substrates [4], much work is still required. Grant applications are also sought to develop other novel substrates, such as lateral epilayer overgrowth (LEO) of GaN films on Si, to reduce defect and dislocation densities. A substantial effort must be made to determine whether it is possible to provide a substrate material that allows epitaxial growth of AlGaInN materials without significant lattice mismatch; this would require research on alternative approaches such as layered epitaxy overgrowth, pendeo-epitaxy, and strain compensation.

b. Phosphide-Based LEDs - The aluminum gallium indium phosphide material system, $(Al_xGa_{1-x})_{0.50}In_{0.50}P$, is nearly lattice-matched to gallium arsenide (GaAs) and has dominated applications requiring high-brightness red, orange, and or amber LEDs. For aluminum compositions ranging from from x = 0 to x ~ 53 percent, corresponding to peak wavelength emission from about 650 nm (deep red) to nearly 555 nm (yellow-green) [5], this material system provides direct-band-gap recombination of the carriers. The reduction of internal quantum efficiency with increased Al composition has been studied, and the dominant mechanisms have been identified through measurements of carrier leakage and by locating indirect band minima. Also, the extraction efficiencies of the available geometries have been well mapped out. Grant applications are sought to overcome some of the remaining challenges, leading to the cost effective utilization of this material system in general lighting. Areas of interest include: (1) band-gap engineering for improved carrier confinement; (2) inexpensive methods for high-extraction efficiency; and (3) control and reduction of degradation mechanisms under high-current, high-temperature operation.

c. Phosphors for Blue and Ultraviolet LEDs - The recent development of white-light LEDs has been based on the phosphor-assisted conversion of blue radiation (wavelength of 450 - 470 nm) from the LED into yellow light. The phosphor, yttrium aluminum garnet (YAG), activated with trivalent cerium (Ce^{3+}:YAG), converts the blue LED radiation into a very broad band yellow emission. The emission is centered at about 580 nm with a full-width-at-half-maximum linewidth of 160 nm. The emission of Ce^{3+}:YAG contains enough orange emission to produce 'white' light at a color temperature of 8,000 K and an efficacy of about 15 lm/W. Although color temperature can be lowered by using more phosphor, the system efficacy decreases. Other problems associated with the production of pseudo-white light by combining a blue LED with a yellow phosphor include: the halo effect of blue/yellow color separation due to the different emission characteristics of the LED (directional) and the phosphor (isotropic); the low color rendering index; and the color shifts (from blue to yellow) with aging and variations in drive current. Grant applications are sought to develop "white light" phosphor coated LEDs having higher efficacy and a lower color temperature. Areas of interest include: (1) developing phosphors that strongly absorb (greater than 90 percent) at the wavelength of the LED radiation; (2) identifying strong red, green, and blue phosphors suitable for generating white-light; (3) developing phosphors with intrinsic efficiencies (defined by the ratio of the emitted photons to absorbed photons) 85 percent or higher; and (4) finding phosphors that display excellent lumen maintenance (defined as the change in lumens/brightness with time).

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PROGRAM AREA OVERVIEW - ENERGY EFFICIENCY AND RENEWABLE ENERGY

http://www.eren.doe.gov

The mission of the Office of Energy Efficiency and Renewable Energy (EE) is to lead the nation to a stronger economy, a cleaner environment, and a more secure future through development and deployment of sustainable energy technologies. EE develops technologies that protect the environment and support the nation's economic competitiveness through a program of research, development, and market deployment using private sector partnerships. EE is organized around the four main energy users -

power, industry, transportation, and buildings - an orientation that has helped the technology development programs focus on addressing the needs of the marketplace.

It is estimated that the energy technologies and practices supported by the Energy Efficiency and Renewable Energy program have saved Americans ten to fifteen billion dollars in energy costs over the past decade. These savings continue to mount as new energy technologies developed by the program for buildings, transportation, power and industry are put to use and as research continues. These energy savings are accompanied by parallel reductions in the emission of pollutants that affect human health and in the production of greenhouse gases.

14. APPLICATIONS OF NEW TECHNOLOGIES FOR GENERAL ILLUMINATION PURPOSES

Electricity consumed for general lighting applications in commercial and industrial buildings, residences, and outdoor applications represents more than 20 percent of the total U. S. electric energy production. The U.S. Department of Energy maintains an active program to explore new methods by which high quality electric light can be produced with less energy and less environmental impact. Despite concentrated efforts from both government and industry, the efficiency of converting electric energy into visible light by commercial light sources has increased only incrementally over the last three decades. While there have been some significant recent advances in light sources, such as the compact fluorescent lamp, no truly revolutionary new light sources have been developed and commercialized since the mid 1960s. Increases in lighting system efficiency have come primarily through substitution of one type of lamp with another and the addition of sophisticated controls.

The potential for substantial increases in light source efficiency is significant. Even the most efficient of today's sources convert only about 30 percent of the electrical energy into visible light. The technical potential exists to increase light production efficiency by a factor of two or more. The realization of this high level of performance will require major improvements in basic light producing technologies present in existing lamp types (incandescent, fluorescent and high intensity discharge types) and emerging technologies such as solid state light sources. New applications of cutting edge technologies for lighting system controls and ballasts will also be required to fully realize the potential of these new sources.

Grant applications submitted to this topic must be compliant with the Lighting 2020 Vision Road Map and must address the potential for significant efficiency improvements, rather than incremental advances to existing technology. All grant applications must include clear commercialization pathways and estimates of energy conservation potential. **Grant applications are sought only in the following subtopics:**

a. Electronics in Lighting - Grant applications are sought to integrate the immense computational and data processing power represented by contemporary electronics into products used for general illumination purposes. Aside from a relatively small number of specialized controls and dimming electronic ballasts used in fluorescent lighting, these advanced electronics technologies are not well exhibited in most general illumination products. Areas of interest include: (1) inexpensive and microminiature power supplies designed to produce optimum supply voltages and current for inexpensive, dedicated compact fluorescent lamps; (2) fully integrated lamps and associated controls for autonomous daylight harvesting; (3) intelligent ballasts that automatically sense the configuration and power requirements of a fluorescent lamp; (4) universal ballasts that can efficiently power a wide range of fluorescent lamps with differing output power; (5) using semiconductors to permit devices to operate on a range of supply voltages or integrated semiconductors with individual, device-specific addresses and memory; (6) increasing the efficiency of ballasts designed for other lamp types such as Compact Metal Halide or other discharge types; and (7) Internet-type communication protocols to allow systematic dimming or building-wide reduced energy consumption or audits.

b. Improved Incandescent Lighting - About 37 percent of lighting energy use is consumed by incandescent lamps. Existing incandescent lighting technology provides practical and inexpensive solutions to numerous lighting applications including many residential, decorative, and specialty uses. While alternatives to the incandescent lamp are available to achieve large reductions in electric lighting energy consumption, there may always be a need for producing light based upon the incandescence of electrically heated filaments or conductive substrates. With existing incandescent lighting products operating at 10 to 20 lumens per watt, ample opportunity exists to increase efficiency while still relying upon the basic incandescent process. Therefore, grant applications are sought for technology to significantly increase the efficiency and efficacy of incandescent light products. Areas of interest include improved filament radiation, IR reflection, and power conditioning.

***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

c. New Solid State Light Source Material - Many candidate organic and inorganic materials have been examined for use in semiconductor devices that produce monochromatic light. For conventional LEDs, traditional 3-5 materials and substrates exhibit the potential to overcome certain internal quantum efficiency barriers; however, there are many other technical obstacles to overcome before it would be practical to produce high luminous outputs at the very low costs necessary to make a practical general illumination source. Therefore, grant applications are sought for innovative materials research leading to a substantial increase in device efficiency, especially for the generation of broadband, white light. Areas of interest include alternative material choices that are more closely aligned with efficient phosphor performance, and novel combinations of organic dyes and dopants that may shift spectral outputs to more desirable regimes. Grant applications must be for general-purpose illumination (not for information displays or for monochromatic, low lumen output specialty applications), address specific materials science opportunities, include predictions of light production efficiency, and discuss the theoretical and practical limits of the subject technology.

d. Novel Structures and Designs for Solid State Devices - Existing semiconductor light producing devices may not be optimally configured for general illumination applications. External quantum efficiencies may be low, and other geometric optical limitations may impose performance constraints that limit overall device efficiency. In addition, existing devices are costly to manufacture and depend upon labor-intensive crystal growth technologies. Therefore, grant applications are sought for innovative device designs that could potentially overcome these known limitations by taking large, quantum steps forward in optical efficiency. Areas of interest include alternative geometrical designs, matrices, or arrays of existing device designs to overcome such physical limitations as heat dissipation and low optical efficiency. Other novel device designs that promise even more device efficiency are also sought. Grant applications must be for general purpose illumination (not for information displays or for monochromatic, low lumen output specialty applications), address basic conceptual design issues packaging concepts, include predictions of light production efficiency, and discuss the theoretical and practical limits of the subject technology.

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15. INTEGRATED SYSTEMS FOR ENERGY-EFFICIENT SPACE CONDITIONING

Significant advances in the state-of-the-art in building envelope components and in heating, ventilating, and air-conditioning (HVAC) systems for small buildings have taken place over the past two decades. Nonetheless, $15 billion worth of energy is wasted in residential and light commercial thermal distribution systems, and an equivalent amount is wasted because of poorly installed or degrading equipment. Therefore, great potential exists for further improvements in energy efficiency and delivered thermal comfort. Areas of opportunity include systems integration, in which two or more parts of these building systems are jointly optimized, automated monitoring, and adjustment of system parameters. **Grant applications are sought only in the following subtopics:**

a. Equipment for Low Air Flow HVAC Systems - Recent research has identified a three-part strategy for greatly reducing the energy requirements for space heating and cooling in newly designed homes: (1) minimize the air-flow requirement, (2) pre-cool the ventilation air, and (3) place all ductwork within the conditioned space. The most efficient way to minimize the air-flow requirement would be to minimize the peak cooling load through good insulation practice, optimal design and placement of windows, and use of a low-infiltration, "tight" building envelope. The ventilation air could be pre-cooled by bringing it into one location and passing it over the cooling coil before it mixes with the house air; this would permit twice as much enthalpy to be removed from the air compared to a standard air-conditioning system. The first two principles interact to facilitate the third, because reducing the required airflow makes it possible to downsize the ducts, making them easier to hide. Although the energy-savings potential of this overall strategy is large, it requires an equipment package that operates on the ventilation air only at some times, and on recirculated air plus ventilation air at other times (when loads are higher). In addition, the two air streams must remain separate until after they have passed over the cooling coil. Grant applications are sought to design and develop the above-described heating/cooling appliance. Collaboration with a medium-to-large volume builder is encouraged to facilitate testing in actual houses and adoption of the technology within the industry.

b. Continuous Commissioning of HVAC Systems - While great attention has been paid to the design and manufacture of HVAC systems for small buildings, little thought has been given to ensuring that these systems are properly installed or that the operating parameters are maintained over time. A system capable of self-monitoring ("continuous commissioning") would use active test signals, on-board evaluation, and equipment adjustment in response to those signals. Such a system would have greater energy efficiency and improved thermal comfort, not only at the initial installation but also over the useful service life of the equipment. Grant applications are sought to develop a generic approach to heating and air-conditioning systems that are capable of monitoring important parameters (including system air flow, refrigerant charge, power draw, delivered air temperature, and humidity - as many as possible), self-diagnosis, and adjustment. Environmental conditions that might require adjustment include restrictive return ductwork, restrictive supply ductwork, high inlet humidity due to return leaks, etc. Proposed approaches must be readily adoptable by all manufacturers of HVAC equipment and reflect the cost constraints associated with this industry. Teaming with a manufacturer of HVAC equipment would be a significant advantage.

c. Low-Loss Distribution System for Modulating HVAC Equipment - HVAC equipment that modulates output to match heating and cooling requirements as they vary during the day offers higher energy efficiency and improved comfort in residential applications. However, along with system output, the modulating equipment varies the airflow in the distribution system. Because the distribution systems are sized for full-load airflows, they become inefficient when operating at reduced flow rate conditions; i.e., the increased residence time of the heated or cooled air inside the ducts results in greater heat losses or heat gains to the conditioned air. Consequently, these modulating HVAC systems require much more insulation, especially when ducts are installed in unconditioned spaces such as attics (a typical duct location for most new slab-on-grade construction today). Grant applications are sought to develop and test alternative distribution systems that would eliminate the additional losses at low-flow conditions for modulating HVAC equipment.

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16. HYBRID ELECTRIC VEHICLE TECHNOLOGY

The development of advanced transportation technologies could reduce propulsion system cost and weight while improving energy management controls in electric and hybrid electric vehicles with ultra-low emissions and very high fuel efficiency. This topic deals with soft switching power converters, improved battery performance, integrated controller-motors, and innovative power transmissions. Goals include reductions in cost, weight, and size while improving the overall power efficiency, performance, and driving range. Proposed approaches must show how the technologies can be applied to large volume manufacturing and must also be affordable, both in procurement costs as well as in operating costs. Research efforts are expected to involve multi-disciplinary teams of scientists and engineers. **Grant applications are sought only in the following subtopics:**

a. Soft-Switching Bi-Directional DC/DC Converters - In hybrid electric vehicles, high power bi-directional DC/DC converters are used to connect a battery to the high voltage traction DC bus. Usually, these converters use hard-switching techniques due to the complexity and high cost of the bi-directional soft-switching topologies. At least half of the power losses in the converters are attributed to heat losses associated with this switching, leading to high operating temperatures. Additional semiconductor devices with better switching capabilities can be used to keep junction temperatures within limits, but this increases the cost, size, and weight of the DC/DC converter. Semiconductor heat dissipation also limits the switching frequency of the hard-switching converters, and the lower switching frequency results in increased size and weight of the magnetic components, further increasing converter size and weight. Therefore, grant applications are sought to develop a simple, cost-effective soft-switching topology to reduce DC/DC converter size and weight and improve efficiency. The proposed design should be scaleable in 30 kW to 150kW power range, 150 - 300 V battery voltage range, and 400-800 V DC bus voltage range.

b. Rapid Charging Techniques for Battery Systems - Current technology for energy storage systems in vehicles and stationary applications typically require approximately the same length of time for recharging as they took to discharge. Many applications, such as energy management, transmission stability, or voltage support could benefit from much shorter recharging times. Greater power flow into the battery would provide much better flexibility in responding to varying load and supply. Grant applications are sought for techniques that would substantially reduce the time required to recharge stationary or vehicle battery systems. Proposed approaches may include use of pulsed charging regimes or changes in battery architecture.

c. Innovative Concepts for Integrated Controller-Motors - Advances in integrated traction drive controller-motors are needed to meet joint program goals for motors and control power electronics in propulsion applications. Propulsion systems must deliver constant power over the entire speed range. As the vehicle reaches higher speeds, less torque is required from the drive system than at low speeds. In conventional vehicles, a constant power ratio of 4:1 is accomplished by using a multi-speed transmission. However, in electric and hybrid electric vehicles, a transmission, along with its higher cost and reduced efficiency, would be unnecessary if the electric motor can provide the same result. A high performance DC brushless permanent magnet motor (with greater than 98 percent efficiency) would be an attractive candidate for these propulsion systems. Unfortunately, they provide "constant" torque rather than constant power throughout the speed range. To compensate, larger control system inverters must be used, adding to size and weight. Grant applications are sought to develop a 30 kW, 300 volt integrated controller-motor that (1) provides at least a 4-to-1 constant power ratio over the entire speed range, (2) maintains the ultra-high efficiency of high performance DC brushless permanent magnet motors, and (3) does not require an oversized inverter. Proposed approaches should draw from new electromagnetic, cooling and control technologies that are lighter, more compact, and more reliable than those in use today. Grant applications should demonstrate improved system performance, reliability, and cost over conventional, non-integrated methods. As a reference, the cost and power density goals for a 30 kW, integrated controller-motor are $10/kW and 5 kW/kg, respectively.

d. Improved Fuel Efficiency with Optimized Power Trains - Improving the efficiency of conventional automotive internal combustion engines (ICE) and hybrid electric vehicles are key elements of the overall strategy for reducing vehicle related pollutant emissions and fuel consumption. A continuously variable transmission (CVTs) is a candidate solution that would require little modification to an ICE vehicle in order to operate near its optimum point throughout the driving cycle. However, current CVT systems deliver only enough torque for light duty applications. Therefore, grant applications are sought for novel CVT designs that can deliver sufficient torque, durability, and reliability to function with hybrid electric vehicles and ICEs used in today's automobile fleet (i.e., 1.8 liter displacement and greater). Proposed approaches for CVT control systems should address the critical operational issues of fuel economy and impact on vehicle driving characteristics. It is recognized that for novel designs, these issues may yet be undetermined and therefore the development of metrics quantifying these characteristics should be addressed Phase 1.

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17. IMPROVED FUEL QUALITY FOR BIODIESEL AND RELATED APPLICATIONS

Fuel switching represents the most direct route to expanding the use of renewable energy sources by U.S. energy customers within the existing transportation and power generation infrastructure. In particular, the potential market for biodiesel fuel is enormous. Thirty billion gallons of diesel fuel are used each year in the U.S. transportation system. In the power sector, diesel generators provide approximately 80 MW of power, installed as 50-2000kW diesel gensets. The role of diesel fuels would be larger still if air quality concerns did not hamper regulatory acceptance in both energy efficient transportation and peak energy management. The enhancement of biodiesel fuel quality and availability would contribute to high-efficiency trans-portation, reliable power generation, and increased use of renewable technologies. Similarly, addressing air quality concerns by reducing NO_x emissions and ensuring the quality of delivered fuel will have a positive impact on the use of both petroleum and biodiesel fuel in these applications. **Grant applications are sought only in the following subtopics:**

a. Dehydrogenation of Saturated Long Chain Fatty Acid Methyl Esters Used for Biodiesel - Biodiesel fuel properties are influenced by the proportion of fatty acids present in the final fuel. Polyunsaturated fatty acids such as linoleic or linolenic acids provide good cold weather performance, but reduce stability, Cetane number, and lead to high levels of NO_x emissions. Saturated fatty acids, such as stearic and palmitic acids, improve Cetane and stability and reduce NO_x emissions, but create significant cold weather performance issues. The number of double bonds appears to be a key factor in the performance of these fuels (polyunsaturated fatty acids have too many; saturated fatty acids have too few). Several approaches have been tried in search of a reasonable trade-off: blending feedstocks, using a fuel consisting of mono-saturated fatty acid methyl esters, and hydrogenating polyunsaturated fatty acids with selective catalysts to reduce the level of unsaturation (without significantly increasing the fraction of saturates). However, these approaches have achieved only limited success.

As an alternative approach, grant applications are sought for lab or industrial scale demonstrations of technologies that can selectively add double bonds to long chain saturated fatty acid methyl esters (C14, C16, C18) in biodiesel. Among the approaches of interest, catalytic dehydrogenation has been shown to be particularly effective for the production of methacrylic acid from isobutyric acid in the detergent industry (introducing double bonds at positions immediately adjacent to the carboxylic acid functional group). This straightforward, heterogeneous process proceeds in a single step by passing the substrate over a heated catalyst bed. Although the infrastructure for heterogeneously catalyzed processes is well established, other approaches based on homogeneous catalysis may also be available. Proposed approaches should not increase the proportion of polyunsaturated fatty acid methyl esters by more than 5 percent, nor should they add more than 10 cents per gallon to the production cost of biodiesel fuel.

b. Low-Nitrogen Content Oil and Biodiesel for NO_x Reduction - Although the currently accepted NO_x emission factor for oil burners is 0.13 to 0.15 pounds per million BTU (which translates to 100-115 ppm in the flue gas), a 50 percent reduction to 50-60 ppm is achievable with modifications to current technology. This would represent an annual NO_x emission reduction of 38,000 tons. Technologies to achieve this level with oil, and possibly with biodiesel, are considered near-commercial. Grant applications are sought for yet further reductions in NO_x emission levels to the order of 20 ppm, which would result in a reduction of 90 percent from current levels. Successful research in this technology would lead to the development of low cost, more reliable, and easy-to-service combustion systems. A low nitrogen content fuel may be assumed for achieving the NO_x target.

c. Contamination Reduction During Storage and Transport - Marked changes can occur to fuel quality during transportation and extended storage. Exposure to heat and water, contamination with debris, and growth of biological organisms all can contribute to the accumulation of gums, sludge, and water. This degradation in fuel quality leads to system fouling and costly service and greatly degrades the efficiency of combustion hardware. Grant applications are sought to develop instrumentation and associated technology for evaluating the storage stability of oil and biodiesel and for determining the presence of sludge and water in tanks.

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18. IMPROVED BLADES, TOWERS, AND POWER ELECTRONICS TECHNOLOGY FOR WIND TURBINES

Wind turbines are coming closer to commercial competitiveness because of the current high cost of natural gas, the future price expectations of natural gas, and the temporary production tax credit. Almost 4000 MW were installed worldwide in 2000, and 1500 to 2000 MW are expected in the United States in 2001. Not withstanding the current installations, improvements in cost/performance are needed to assure the future commercial competitiveness of this technology.

The general options for improving the cost competitiveness of wind technology are improving energy capture and reducing capital, operating, and maintenance costs. This solicitation addresses three important avenues for cost/performance improvements: (1) use of carbon fiber composites for blades, (2) innovative tower concepts for turbines, and (3) development of advanced high efficiency power electronics architectures for variable speed wind turbine generators. **Grant applications are sought only in the following subtopics:**

a. Carbon Fiber Composites for Wind Turbine Blades - Making wind economical in low wind sites will require bigger rotors and taller towers. The use of carbon or carbon/glass hybrid composite materials could exceed current design restrictions and reduce rotor weights as well. For example, a carbon/glass hybrid design could result in a 30 percent reduction in blade weight, a 50 percent reduction in tip displacement under full load, and only a 4 percent increase in cost. However, many technical hurdles remain, not the least of which is fiber compatibility when mixing glass and carbon into a high-strength, fatigue-resistant composite materials suitable for wind turbine blades. Grant applications are sought to use carbon and carbon/glass hybrid composite materials to expand the ability of wind turbines to increase in size while reducing system weight. Areas of interest include, but are not limited to, composite designs for co-mingled fibers, static and fatigue strength of hybrid and carbon composites, bucking strength of large panels constructed from thin plies, manufacturing techniques for mixed materials, and optimized designs for turbine components using hybrid composites.

b. Innovative Tall Tower Concepts - Wind shear is a physical phenomenon in which the velocity of the wind increases as one goes higher above the ground. Since the power in the wind goes up as the cube of the wind velocity, wind turbines at greater heights above the ground would significantly improve energy production and reduce energy cost. However, the classical method for erecting very tall structures using cranes is limited by the availability of very tall high capacity cranes and the costs of transporting very heavy large diameter tower bases. Lighter weight towers would lend themselves more easily to erection and allow for the placement of wind turbines at greater heights. Grant applications are sought for alternative means of fabricating and erecting very tall towers (up to 100 meters above the ground) for wind turbine installation. Areas of interest include: (1) the use of hybrid structures that may be combinations of trusses and poles, (2) composite structures using combinations of fiberglass, steel, carbon, concrete or other cost effective materials; or (3) innovative methods for onsite fabrication and erection that are not dependent upon the use of very expensive cranes. Designs may be built around the concept of self-erection or other simplified methods of erection. Design concepts should reduce overall system costs, component weights, erection costs and time, and transportation costs.

c. Electrical Power Conversion Systems for Variable Speed Wind Turbines - Many commercial wind turbines run at fixed rates of rotation. Although easy to implement and control, a fixed rate of rotation does not optimize the capture of mechanical power from the wind. If the ratio of the rate of rotation of the wind turbine rotor to the inflow wind speed could remain constant, the aerodynamics would be optimized and energy capture could improve by 10 to 30 percent. Electrical power conversion systems (e.g., variable speed drives that are combinations of rectifiers and inverters), designed for the control of variable speed motors and torque, are candidates for the wind turbine application. Although developed for motor control, these drive units could just as easily be applied to convert mechanical power back to electrical power. Also, these designs could lead to the elimination of the gearbox, reducing cost and turbine head weight and increasing reliability by spilling fatigue-driving loads. However, variable speed drives are inefficient at speeds other than the rated speed of the motor. For instance, if the rpm is 50 percent of the rated speed (corresponding to 1/8 the rated power), the efficiency of these drives can drop as low as 50 percent - highly undesirable for the capture and conversion of mechanical power to electrical power. Also such variable speed drives are often large and cumbersome, and are not easily scaled from one machine rating to another without significant re-engineering.

Grant applications are sought to develop innovative variable speed drive topologies for wind turbines, using modern power electronics that are easily scalable and have power conversion efficiencies above 90 percent throughout the full range of operation (from 10 percent rated power to full output). The devices should be applicable to wind energy generators of all sizes, from a few kilowatts up to multi-megawatts. They should be easily packaged, and if possible modular in nature to allow for expansion to different sized machines. Moreover, the desired topologies should be capable of meeting all applicable power quality standards.

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19. ADVANCED MEASUREMENT AND CONTROL IN INDUSTRY

Sensor and control technologies are integral components of all modern processing industries. These technologies are essential to the evaluation and monitoring of product properties and quality, process safety, and energy efficiency of industrial processes. Sensors supply the data that are used to monitor and control product and process variables. Energy intensive industries are likely to invest substantially over the next decades in advanced sensor and control systems. **Grant applications are sought only in the following subtopics:**

a. Small, Low-Cost Infrared and Raman Instruments for Process and Quality Control - Within the chemical, petroleum refining, and pulp and paper industries, among others, chemical composition monitoring would provide information needed to optimize processes, correct unexpected events in real-time, reduce the need for reworking off-grade product, and save energy costs. In distillation processes, for example, some chemical stills have experienced savings of $200-300 thousand per year following optimization and control using composition analyzers. Energy costs would also be saved by reducing unnecessary heating times within reactors, reducing the time between product changes, or reducing the length of hold-times when waiting for a lab analysis. Improved safety for workers and minimization of physical damage from runaway reactions or explosive situations are also important considerations.

To address this need, grant applications are sought for a new generation of infrared (IR) and Raman spectroscopic instruments that are relatively small in size (inches), cost approximately $10-15 thousand, and can be installed at manufacturing sites as complete systems. Although on-line mid infrared and Raman instruments are commercially available, they are both costly ($100,000) and relatively large (several feet high, two to three feet deep, and two to three feet wide). Also, they may require expensive replacement parts and specialized maintenance by trained personnel. Either new or currently available small instruments are of interest, modified into complete systems (i.e., including sampling systems, protective housing, software, etc.) and free of stability problems or other technical difficulties. For IR spectroscopy, diode lasers with wide tunable ranges are needed. Raman spectroscopy requires new, low-cost, stable, high-intensity and high-resolution lasers, as well as techniques, either physical or mathematical, for dealing with the interference from fluorescence. For both IR and Raman, low-cost, room-temperature detectors are needed for size reduction and ease of operation, and new data-treatment approaches are required to best utilize available technology (e.g., methods to maximize the information content from lower-resolution monochromators).

b. High Throughput Microinstrumentation for Process Optimization - To achieve the highest level of process quality, the Six Sigma quality control method teaches that processes should be designed from the beginning for minimum variability. For example, in reaction systems, operating parameters should be selected in regions that are less sensitive to operating condition variations, thus allowing the production of product that is always in-specification. Producing in-specification product eliminates the need for storage/rework or disposal of off-specification material. Some industry experts believe that yields could be improved by at least five percent in each new process that could be so optimized. The difficulty is finding the optimum set of operating conditions among the myriad of possibilities.

High throughput experimentation is an emerging technique for examining a large number of process variables in order to find an optimum set. These techniques have three major components that need to be mated and then automated: (1) the material transformation system (the reaction itself), (2) the property evaluation system, and (3) the data analysis and control system. Microfluidic systems, including micro-reactors and micromixers, are well-suited for the material transformation system due to their rapid response times. These microfluidic systems are just now being introduced into the market; however, they must be coupled to high speed, high sensitivity analytical devic es and data systems for high throughput experimentation to be effective. Grant applications are sought to develop an integrated system, which couples emerging microreactor systems with sensors and data analysis systems to enable high throughput experimentation to be used for process development.

c. A System for Measurement of Energy Use in Industrial Heating Applications - Industrial heating processes for the production of materials use large amounts of energy. Energy consumption depends on a number of factors associated with the design, operation, and maintenance of the heating equipment. Currently, no simple method is available for measuring and reporting the energy used per unit of production, or during a certain production cycle, for fuel fired systems that use gaseous (natural gas) or liquid (fuel oil) fuels. In most cases it is not possible to measure even average energy consumption over a time period such as an hour or a day. These fuel fired systems account for the vast majority of all heating systems, including steam boilers and process heating systems. Grant applications are sought to develop a simple energy or fuel measurement system for monitoring fuel usage per unit of production in industrial heating applications. Such a system would enable the operator and management to identify process and equipment inefficiencies, account for the role of energy in production cost, and schedule preventive maintenance.

Proposed devices should monitor instantaneous energy consumption as well as an integrated value over a desired time period or production cycle. An interface to the fuel supply system should be included (for the energy input data) as well as control instruments (such as a temperature controller or an integrated process control system) for reporting the desired information. A non-intrusive system or sensor that does not require modification to the energy supply system (i.e. fuel supply piping) is preferred. System design should maintain a balance between measurement accuracy and acceptable costs - reasonable targets would be an accuracy of +/- 1 percent at a cost on the order of $1000 under mass production for small to medium size installations.

d. Improved Near- and Mid-Infrared Laser Light Source for Industry - Near-infrared and mid-infrared lasers have been effective as light sources in spectroscopic-based sensor systems. However, current applications are limited by the wavelengths of commercially available lasers, driven by the large telecommunications market. Grant applications are sought to develop low-priced lasers with broader wavelength ranges, especially in either the near-infrared (NIR) or mid-infrared. Such development would open significant new applications in a variety of industries and perhaps stimulate the development of new spectroscopic approaches. For example, lasers with wavelengths in the range of 1-5 microns would have applicability for sensors used in the chemical industry. Extension of the wavelength to 6.5 microns would improve the sensitivity for gas measurements important in combustion analysis (nitrogen oxides, CO, CO_2, SO_2, etc.). Other applications include temperature and composition measurements for combustion control, composition measurements for control of chemical processes, hazardous gas monitoring, and emission monitoring and control. Many current applications are aimed at vapor phase analysis of molecules small enough to have resolved rotational/vibrational absorption bands. In such applications, the light source must have a bandwidth narrower than the absorption bands (<100 MHz), enabling a number of novel electronic schemes to extract the signal. The laser also should have a coarse tuning range of 10 wavenumbers and a fine-tuning range of 0.5-1.0 wavenumber.

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PROGRAM AREA OVERVIEW
HIGH ENERGY PHYSICS

http://hepserve.fnal.gov:8080/doe-hep/links.html

Through fundamental research, scientists have found that all physical matter is composed of apparently point-like particles, called leptons and quarks. These constituents of matter were created following the "big-bang" which originated our universe and they are components of every object that exists today. We also understand a great deal about the four basic forces of nature which we experience: electromagnetism, the strong-nuclear force, the weak force, and gravity. For example, in the past we have learned that the electromagnetic and weak forces are two components of a single force, called the electro-weak force. This is analogous to the conceptual unification in the mid-nineteenth century of the electric and magnetic forces into the theory of electromagnetism. History shows that, over a period of many years, the understanding of electromagnetism has led to many practical applications that form the technical basis of modern society.

The goal of the Department's High Energy Physics (HEP) program, is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental research mission. Such fundamental research provides the necessary foundation that enables the nation to progress in its science and technology capabilities, to advance its industrial competitiveness, and to discover new and innovative approaches to our energy future.

Experimental research in HEP is primarily performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago, IL and the Stanford Linear Accelerator Center (SLAC) near San Francisco, CA. Further, the Department has a significant role in the Large Hadron Collider project at the CERN laboratory in Switzerland. The Tevatron at Fermilab is currently the world's highest energy accelerator. SLAC also provides unique experimental capabilities.

While much progress has been made during the past three decades in our understanding of particle physics, future progress depends on the availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

Within High Energy Physics, the High Energy Technology subprogram supports the research and development required to extend relevant areas of technology in order to support the operations of highly specialized accelerators, colliding beam facilities, and detector facilities which are essential to the goals of the overall High Energy Physics program. The Department of Energy SBIR program provides a focused opportunity and mechanism for small businesses to contribute new ideas and new technologies to the pool of knowledge and technical capabilities required for continued progress in high energy physics research, and to turn these novel ideas and technologies into new business ventures. The technical topics that follow include four accelerator-related topics and two detector-related topics.

20. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS

The Department of Energy (DOE) High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in the following areas: (1) new concepts for acceleration, (2) novel device and instrumentation development, (3) inexpensive electron sources, and (4) computer software that will contribute to overall advances in accelerator technology applicable to the High Energy Physics program. Relevance to applications in high energy physics must be explicitly described. Advanced accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 29. Grant applications that propose using resources of a third party (such as a DOE Laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. New Concepts for Acceleration - Grant applications are sought to develop new or improved acceleration concepts. Designs should provide very high gradient (>100 MeV/m for electrons or >10 MeV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. One possible concept might include the fabrication of accelerator structures from materials such as Si or SiO_2, using integrated circuit technology; in this case, power sources might include lasers in the wavelength range from 1 to 2.5 micrometers. For all proposed concepts, stageability, beam stability, manufacturability, and high wall plug-to-beam power efficiency must be addressed in detail. Grant applications must also address the marketability of any systems, technologies, and devices to be developed.

b. Novel Device and Instrumentation Development - Grant applications are sought for the development of electromagnetic, permanent magnet, or silicon microcircuit-based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, dipoles, quadrupoles, higher order multipole correctors for use in electron linear accelerators, and solenoids for use in electron-beam or ion-beam sources or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.1 to 10 cm. In these optical elements, permanent magnets or hybrid magnets incorporating magnetic materials that have very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest. Also of interest are field probes for measuring silicon microcircuits with effective apertures down to 5 micrometers.

Grant applications are also sought for: (1) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution or emittance, or phase-space distributions of small radius (0.1 micrometers to 5 millimeters diameter), short length (10 micrometers to 10 millimeters) relativistic electron or ion beams; (2) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive or minimally perturbative to the beams monitored and have computer-compatible readouts); and (3) lasers for laser-accelerator applications which provide substantial improvements over currently available lasers in one or more of the following: longer wavelengths (2 to 2.5 micrometers for use with Si transmissive optics), higher power, higher repetition rates or shorter pulse widths.

Grant applications are also sought for the development of novel devices and instrumentation for use in the cooling (transverse and longitudinal emittance reduction) of muon beams. Approaches of interest include the development of: concepts or devices for ionization cooling, including emittance exchange processes; instrumentation for muon cooling channels with muon intensities of 10^{12} muons/pulse;

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or fast (of order 10 picosecond) timing detectors for muon cooling experiments with low muon intensity (of order 10^5 muons/second).

c. Inexpensive High Quality Electron Sources - Grant applications are sought for the design and prototype fabrication of small, inexpensive (<$1 million) electron sources for use in advanced accelerator R&D laboratory experiments. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance less than or equal to 5 pi mm-mrad; and (3) pulse repetition rate greater than 10 Hz.

Grant applications are also sought for significantly lower bunch charges, energies, and emittances but with comparable or greater peak currents and significantly higher repetition rates for bunches from a matrix cathode. In addition, grant applications are sought to develop a bright DC/RF photocathode electron source combining a pulsed high electric field DC gun and a high field RF accelerator operating with similar electron bunch specifications as shown above, but at a repetition rate of several kHz.

Grant applications are sought for the development of radio frequency photocathodes (robust, with quantum efficiencies >0.1 percent) or other novel rf gun technologies operating at output electron beam energies >3 MeV. Laser or electron driven systems for such guns are also sought.

Cathodes are needed for vacuum-electronic devices such as klystrons, gyrotrons, and high brightness electron sources for accelerators. Currently, they have many limitations: conventional thermionic cathodes are limited to about 10 amps/cm^2; reservoir cathodes can operate at higher temperatures and can deliver up to 40 amps/cm^2, but may have life limited by the build-up of deposits from the evaporated barium oxide; photocathodes require expensive lasers, and plasma cathodes have limited life. Therefore, grant applications are sought for research and development leading to rugged, long-life cathodes or electron guns that are capable of producing current densities and currents (several hundred amperes pulsed) comparable to or greater than thermionic emission devices. Applications must focus on one of the following areas of interest: (1) use of secondary emission to amplify a lower current density beam to generate a higher density one, (2) arrays of field emission needles or knife edges (these have been studied extensively but are still easy to damage and hard to use), (3) hybrid, laser-assisted and gated matrix cathodes using back illumination with lasers whose output matches the emitter array, (4) use of field emission from diamond films or other surfaces at higher pulsed fields (flat diamond films have been found to yield significant current densities with relatively low fields), (5) use of ferroelectric cathodes, or (6) new methods for bonding evaporated barium oxide in reservoir cathodes -- because evaporated material sometimes peels off and causes breakdown, improved bonding could increase the lifetime of devices using such cathodes.

Grant applications are also sought to develop a sheet-beam, gridded, thermionic, dispenser-cathode gun for use in a 250 kV, 80 MW X-band (11.4 GHz), sheet-beam klystron. Parameters of the cathode are 100 cm^2 of cathode area, cylindrical or flat geometry, aspect ratio (cylinder length to segment width) of 2:1, and cathode current loading of 5 A/cm^2. Grantees will work closely with engineers in the SLAC Klystron Department to match cathode design with klystron parameters. A gridded, short-pulse klystron may provide an alternative to a pulse compression system, such as for a linear collider.

Lastly, grant applications are sought for research and development on gated electron sources with pulses or pulse trains larger than 0.1 microsecond at about 100-200 pulses per second, and on semiconductor photocathode sources of electrons with polarization in the range of 80 percent and energy in the range of a few volts to several hundred kilovolts. In addition, intensity stability <1 percent is required for polarized beams in pulsed linacs.

d. Computer Software - Grant applications are solicited for developing new or improved computer software specifically for the design or study of charged particle beam optical systems, accelerator systems, or accelerator components. Such applications should incorporate the innovative development of user-friendly interfaces with emphasis on graphical user interfaces and windows. Grant applications are also solicited for the conversion of existing codes to incorporate such interfaces, provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate.

Grant applications are also sought for improved software for command and control functions, real time database management, and status display systems encountered in state-of-the-art approaches to accelerator control.

In addition, grant applications are sought for improved management of integrated cost, schedule, and resource database information for planning and control of large High Energy Physics program R&D and construction projects, such as the Next Linear Collider.

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21. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS

The Department of Energy (DOE) High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in (1) high gradient accelerator structures, (2) high peak power radio frequency (rf) technologies, and (3) new concepts for low-cost, very efficient, pulse power modulators. Relevance to applications in high energy physics must be explicitly described.

Advanced accelerator R&D more appropriate to applications in nuclear physics is specifically excluded from this topic and should be submitted under Topic 29. Grant applications that propose using resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Radio Frequency Acceleration Structures - Grant applications are sought for research on very high gradient rf accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >100 MeV/m for electrons and >10 MeV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. For use in muon accelerator R&D, achieving gradients of 5-10 MeV/m for cavities with frequencies between 20 and 200 MHz is also of interest. Means for achieving unloaded voltage gradients >25 MeV/m and reducing costs in superconducting cavities are also of interest, as are methods for reducing surface breakdown and multipactoring (such as surface coatings or special geometries) and for suppressing unwanted higher order modes. Grant applications should be applicable to devices operating at frequencies from 1.2 to 100 GHz or between 20 and 200 MHz for muon accelerators.

b. Radio Frequency Power for Linear Accelerators - Grant applications are sought for new concepts, high-power rf components, and instrumentation for producing high peak power (>50 MW at 10 GHz, appropriately reduced when scaled to higher frequencies), narrow band, low duty-cycle, low pulse repetition frequency (approximately 0.1 to 1 kHz) pulsed rf amplifiers for application to upgrading future large electron/positron linear colliders. Potential electrical efficiencies greater than 45 percent are considered essential. Innovation related to cost saving, manufacturability, and electrical effic iency is especially sought. Some examples follow:

(1) One way of providing rf power is the cluster klystron, a device consisting of a "cluster" of separate magnetron gun driven klystrons that share a common focusing field and accelerating gap. Such a device could give high total pulsed power with relatively small individual beam currents, and thus be capable of high efficiency. The use of magnetron guns allows the many beams to be enclosed in a compact space, and have modulation anodes that allow the current to be switched, thus eliminating the need for a pulsed high-voltage modulator.

Therefore, grant applications are sought to develop cluster klystrons, as well as highly stable magnetron guns for cluster klystrons.

(2) Another device for providing high rf power is the co-axial gyroklystron. One design has an input frequency of 8.57 GHz and output frequency of 17.14 GHz. This microwave amplifier requires a Magnetron Injection Gun (MIG), (500 kV, 800 A, pulse duration of 2 microseconds, pulse repetition frequency < 60 Hz) to produce an annular beam of spiraling electrons. R&D is required to improve the uniformity of electron emission from the annular cathode emitter, and to improve high voltage standoff of the electron gun insulator. Therefore, grant applications are sought to develop MIG cathode structures, single or segmented, for a MIG-type electron gun meeting these needs, or to develop the whole gun structure including the gun optics and high-voltage ceramic insulator design.

Upgrades to the next generation linear collider will require many rf power handling components which are not presently available, e.g., rf windows, couplers, mode transformers, rf loads, and high power rings capable of operating at high pulse powers (20 - 100 MW), high frequencies (11 - 100 GHz), and pulse lengths of several microseconds. Grant applications are sought for passive and active rf components such as over-moded mode converters from rectangular to circular waveguide and vice versa, high-power rf windows, circulators, isolators, switches, and high-power rf pulse compression methods for use in future linear colliders.

Lastly, grant applications are sought for: (1) higher efficiency rf sources working around 1.3 GHz with power levels up to 50 MW and pulse width of a few hundred microseconds with applicability to two-beam accelerators; and (2) higher efficiency (>65 percent) 1.0 GHz or higher frequency sources appropriate for a superconducting-rf option for a linear collider (such sources should provide a few MW of power, 2-10 milliseconds pulse length, and 5-100 Hz repetition rate (includes continuous wave).

c. New Concepts or Components for Pulsed Power Modulators and Energy Storage - Most rf power sources for future linear colliders require high peak-power pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 400 kV - 1 MV range for driving currents of 400 - 800 A, with pulse lengths of 0.2 - 2 microseconds, and rise- and fall-times of less than 0.2 microsecond. Innovation related to cost saving, manufacturability, and electrical efficiency in modulators is especially important. Modulators with improved voltage control for rf phase stability in some alternate rf power systems are also sought.

Grant applications are also sought to develop high power solid-state switches, either Insulated Gate Bipolar Transistors (IGBTs) or Thyristors, for pulse power switching. Requirements include the ability to switch high current pulses (2-5 kAmps) at voltage levels of 2 to 6 kV with switching times of less than 300 nsec. Construction and low inductance packaging techniques must be developed to allow current state-of-the-art chip designs to handle very high di/dt (20 kAmps/microsecond) at low duty cycle (<0.1 percent).

Grant applications are solicited for the design, development, and computer modeling of a multiple, concentric, high-voltage cable that provides primary pulse energy storage for a klystron electron gun when pulsed, while also connecting the klystron to a remote grid pulser and power supply system. This power scheme would use a high voltage, multiple concentric conductor cable to store the energy delivered during the short, several hundred nanosecond, klystron cathode pulses. The pulse repetition frequency of these pulses is on the order of 100-300 Hz. The dynamic impedance of the klystron during the pulse is on the order of 750 ohms. A typical cable impedance for this sort of cable design is 35 ohms. Thus, if the cable is initially charged to 5 percent over required cathode voltage, then when the grid is pulsed and the cathode delivers full current, the cable voltage on the load end should drop to the required cathode voltage, and this voltage should be maintained until the wave-front, launched on the cable as the result of the grid switched cathode current, travels to the other end of the cable and returns to the load end. At this time, the grid would turn off the cathode current, canceling the returning wave. This dictates that the cable must have an electrical length of exactly half the cathode pulse width. The cable would then recharge slowly during the interpulse period. The cable must have good DC high voltage stand-off characteristics, while also having very low loss and dispersion functions for the traveling waves. Power systems incorporating such high voltage cables are also desired.

Lastly, grant applications are sought to develop and optimize high reliability, high energy density energy storage capacitors for solid state pulse power systems. The capacitors must: (1) deliver high peak pulse current (5 - 8 kAmps) in the partial discharge region (less than 10 percent voltage droop during pulse), (2) be designed with very low inductance connections to allow fast rise and fall time discharge without ringing (di/dt ~ 20 kAmps/microsecond), and (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost.

Note: Grant applications for components and systems that target the presently envisioned Next Linear Collider should be submitted under Topic 23.

d. Radio Frequency Power for Muon Colliders - Grant applications are sought for new concepts, approaches, or designs for radio frequency amplifiers or pulse compression schemes for use in the acceleration and ionization cooling channels of a future muon collider. The amplifiers or compressors must have high peak power (>50 MW), and pulsed, low frequency (in the range 2 millisecond pulses at 20 MHz to 0.1 millisecond pulses at 200 MHz). There is also interest in higher power (>100 MW) pulsed sources at higher frequencies (in the range 30 microseconds at 400 MHz to 10 microseconds at 800 MHz). All muon collider amplifiers must have moderate repetition rate capability (e.g., 15 Hz). Cost per unit of peak power, including that of the needed power supplies, is of particular interest.

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22. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this program in (1) high-field superconductor and (2) superconducting magnet technologies. This topic addresses only those superconductor and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems. Relevance to applications in high energy physics must be explicitly described and will be a factor in the application selection process. Grant applications which propose using resources of a third party (such as a DOE laboratory) must include in the application a letter of certification from anauthorized official of that organization. **Grant applications are sought only in the following subtopics:**

a High-Field Superconductor Technology - Grant applications are sought for new or improved materials, starting raw materials, and related processing techniques for high critical-current, high critical-field conductors to produce low alternating current (AC) loss conductors for use in very high-field magnets. While improvements are sought for magnets above 8 Tesla, the engineering goal for the near future (7 to 10 years) is at least 15 Tesla. Applications must demonstrate such property improvements as higher critical-current densities and higher critical fields, as well as manageable degradation of these properties as a function of applied strain. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K. Process improvements must result in equivalent performance at reduced cost. Advanced conductor fabrication techniques of interest also include methods to utilize high aspect ratio stranded conductors or tape geometries in particle accelerator applications. Materials of interest include: niobium-titanium, ternary niobium-titanium alloys, the so-called "A-15" compounds (e.g., niobium-tin and niobium-aluminum), and oxide (high temperature) superconductors. Regarding oxide superconductors, a minimum current density of 1200 A/mm^2 (not cm^2) in the superconductor itself and a minimum current density of 250 A/mm^2 over a total conductor cross section, at 12 Tesla minimum and 4.2 K, must be achieved. All grant applications for A-15 and oxide superconductors must address the challenge of long length, large volume industrial production for practical applications. The details of such production plans, including expected development time, also must be discussed. Proposals addressing improvement of starting raw materials are encouraged.

High performance niobium-titanium (NbTi) alloys operating above 8 Tesla appear to be required for focusing quadrupole magnets or for "low field" graded windings in higher field dipoles. Grant applications are sought for NbTi composite superconductors whose properties are optimized at the higher field portion of the short sample curve. Grant applications must focus on conductors that will be acceptable for accelerator magnets.

In addition, grant applications are sought for innovative insulating materials which would enable employment of new superconductors, such as the A-15 or oxide types, in practical devices. Insulating materials must be compatible with high temperature reactions in the 750-900?C range and must be capable of supporting high mechanical loads at cryogenic temperatures.

b. Superconducting Magnet Technology - Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current leads based on high-temperature superconductors for application to high-field accelerator magnets, which have requirements that include current level at 5 kA or greater, stability, low heat leak, and good quench performance; (3)

alternative designs, to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets, that may be more compatible with the more fragile A-15 and the oxide, high-field superconductors; or (4) designs for bent (e.g., bending radius of 0.5 meter) solenoids (e.g., 4 T, 30 cm inside diameter) with superimposed dipole fields (e.g., 1 T) for dispersion generation in large emittance beams.

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23. TECHNOLOGIES FOR THE NEXT-GENERATION ELECTRON-POSITRON LINEAR COLLIDER

The DOE High Energy Physics program supports research and development (R&D) of technologies for a TeV-scale electron-positron linear collider that would use normal-conducting X-Band (11.4 GHz) microwave power. This collider will be five to ten times the energy of present-generation linear accelerators. This topic addresses near-to-medium term developments to enhance performance and reliability and/or to reduce costs of accelerator components and infrastructures. Applications should demonstrate relevance to these issues. Any letters included in an application which indicate the use of resources of a third party (such as a DOE Laboratory) must include certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Direct Current (DC) and Pulsed Power Supplies Modulators and Components -Advances are needed in various aspects of pulse modulators and associated components to drive klystrons in both injector and main linac applications. Grant applications are sought for:

(1) DC Power Supplies operating at 2 to 5 kV from about 50 to 500 kW output, to drive capacitor banks in IGBT (Insulated Gate Bipolar Transistor) switched induction modulators or Marx generators. The power supplies must have 0.1 percent regulation, withstand pulsed current duty cycle between short discharges (3 - 6 microseconds) and recharge at 120-180 Hz steady state. Operation for shorter pulses at higher recharge rates is also desired for testing purposes. Other objectives include high reliability, low cost, and efficiency greater than 90 percent.

(2) Ultra-Reliable Capacitors of ~10-25 microfarads at 2.5 to ~6 kV to provide stored energy for partial discharge, on-off switch modulator configurations. Requirements include low loss, low inductance, high power density to minimize volume, MTBF >100,000 hours, and low cost. Long lifetime is a priority because the large numbers of such units in the modulator designs will dominate modulator reliability.

(3) High Voltage Pulse Transformers with ratios from 1:6 up to 1:15, with low leakage inductance and minimized core loss, for use in solid-state-switch driven modulators with a load-matching transformer. The modulators will drive a pair of X-band klystrons at 180 Hz with ~500 kV, 520 A peak and 3 microseconds pulse-length, or drive an S-band klystron in the injector at 180 Hz with 380 kV, 800 A peak, and at least 6 (possibly up to 16) microseconds pulse-length. Rise/fall times of less than 300 ns and droop/ripple of less than 2 percent are desired. Transformers must operate in oil and be compact, efficient, and cost-effective to manufacture.

Further information on this subtopic can be obtained from Ray Larsen at SLAC (e-mail: larsen@SLAC.Stanford.EDU phone: 650-926-4907; fax: 650-926-5124).

b. Manufacturing Processes and Support Technology for Microwave Power - The transmission of high power, X-band microwaves to the high-energy, X-band linear accelerators in the NLC may utilize oversized, multi-mode components and waveguides with non-standard cross sections, evacuated to 10 nTorr pressure. Components for such functions as manipulating microwave modes or introducing mechanical flexibility may be irregularly shaped. They also require demanding tolerances on internal dimensions (mils), surface finishes (microns), leak rates (10^{-12} Torr-liter/sec/cm^2), rf voltage hold-off (40 MV per meter), and surface conductivity (at least as good as aluminum). For these components, conventional manufacturing processes such as investment casting or electroforming are not adequate. Therefore, grant applications are sought to develop appropriate techniques or manufacturing processes to economically produce these microwave components in large batches of identical parts.

Grant applications are also sought to develop or advance net shape or near net shape manufacturing processes for mass production of high-conductivity (100 percent dense), oxygen-free (ASTM F.68 Metallographic Class I) copper components used in ultra-high vacuum (UHV) (equilibrium vapor pressure <1 nTorr at 300?C), high-power microwave applications. Mechanical tolerances of 50-100 micrometers must be achieved. Grant applications are also sought to develop or advance processes for precision machining subsequent to the aforementioned net shaping, with dimensional and flatness tolerances of one micrometer and surface finishes of 10 nanometer (rms). All grant applications, whether addressing net shaping or precision machining, must demonstrate significant cost reduction over current numerically controlled machining methods. Manufacturing processes with similar tolerances and applicability for the mass production of UHV, high-power parts made from stainless steel, aluminum, or copper alloys are also of interest.

Lastly, to support the generation and transmission of high power microwaves, grant applications are sought to develop: (1) a microwave circulator and/or active switch with high efficiency for multi-megawatt power levels at 11.4 GHz [see reference 7]; (2) robust, reliable techniques for distributed pumping and/or for suppression of surface field emission in components and waveguides; (3) robust, reliable techniques for the joining components and waveguide sections in the accelerator housing [see reference 7]; or (4) new permanent magnet focusing structures with reduced cost or improved reliability for X-, S-, or L-band "SLAC-type" klystrons.

Further information on this subtopic can be obtained from John Cornuelle at SLAC (e-mail: johnc@ SLAC.Stanford.EDU; phone: 650-926-2545; fax: 650-926-5124).

c. UHV Manufacturing Techniques for NLC Damping Ring Cavities and Vacuum Chambers - Grant applications are sought to develop ultra-high vacuum (UHV) manufacturing techniques for low-cost, reliable fabrication of UHF-band radiofrequency accelerating cavities with damped higher-order modes for use in damping rings. Fabrication of the cavity and its penetrations has in the past been performed by multi-axis milling of oxygen-free, high-conductivity copper - an expensive process. More cost-effective candidate techniques include stereolithography, casting, electroforming, plunge-EDM, etc. Methods are also required for providing cooling channels that can be accessed from the exterior of the cavity. Methods such as plasma deposition over machined or formed channels, or brazed tubing, may be investigated (in preference to existing electroplating techniques). The joining of parts by electron-beam welding is also of interest.

Grant applications are also sought to develop improved low-cost techniques for the fabrication of damping-ring UHV aluminum vacuum chambers with detailed, non-circular cross-sections and outgassing rates of 10^{-12} Torr-liter/sec/cm^2 or less at room temperature. Machining tolerances are generally approximately ?1 mm over the length of the structure, with detailed features requiring tolerances of approximately ?100 micrometer to be added in a subsequent process. In order to reduce the effective surface area, and thus outgassing rate, the chambers may be extruded, with a final machined surface finish. Other details of the manufacturing process, such as the cleaning process and the choice of machining lubricant are also critical in producing and maintaining low outgassing rates. Other needs include (1) improved methods of joining the vacuum chambers to the stainless steel flanges with UHV-compatible techniques, and (2) the development of a method and equipment to directly measure outgassing rates, in order to evaluate the chamber manufacturing techniques described above. For the latter, requirements include measurements of 10^{-12} Torr-liter/sec/cm^2 or less at room temperature for multiple samples of aluminum or other metals, and minimal sample sizes to lower the costs of preparation.

Further information on this subtopic can be obtained from John Corlett at the Lawrence Berkeley National Laboratory (e-mail: JNCorlett@lbl.gov; phone: 510-486-5228; fax: 510-486-7981).

d. Focusing and Auxiliary Systems - As a potentially more economical and reliable alternative to DC electromagnets, permanent magnets are under consideration for about half of the 6000 beam-line magnets in the NLC. Grant applications are sought for the development of a highly reliable permanent magnet quadrupole that is remotely tunable over a range of ?20 percent relative to its nominal integrated focusing gradient (taking about 10 seconds). The quadrupole must be magnetically stable, with less than 1.4 micrometers of magnetic center shift. These specifications require symmetry and stability not previously sought from permanent magnets and greatly influence the magnetic and mechanical design of the quadrupole. A typical quadrupole will have 13-mm-diameter aperture, 430-mm length, and 0.8-Tesla pole-tip field. The operating environment that is contemplated is 10,000 Rads per year, and stable temperature near 90?F. See reference 1 for more information on this subject.

Grant applications are also sought to develop a translational mover system for an electromagnet in an accelerator beam line. The mover should be capable of repositioning, horizontally and vertically, a 700-kg load in 50-nm steps over a range of ?3 mm, with average speed of 5 micrometers/sec. The resonant vibration frequency of the magnet-mover system should exceed 20 Hz.

In order to ensure stable collisions of nanometer-size NLC beams, the relative and absolute motion of the final focussing magnetic lenses, which are separated by 6-8 meters, must be suppressed to less than or approximately 1 nm amplitude at frequencies above 5 Hz. Therefore, grant applications are sought to develop techniques and components of a new vibration suppression system. With sub-nanometer accuracy in the frequency range above a few Hz, it must be capable of sensing and suppressing relative and absolute motion of long, separated massive objects. The objects may reside in a 3-6 T external magnetic field from the solenoid of the high energy physics detector. The separated objects may be either: (1) 0.5 ton, 3-m long, electromagnetic or permanent magnet quadrupoles at room temperature, or (2) less massive, 5 cm diameter, 3-m long, cold metal bores of superconducting quadrupoles to be stabilized inside their cryostats.

Finally, sensors and electronic devices are needed for the measurement and control of key NLC features. Grant applications are sought to develop: (1) robust, non-contact position sensors based on radiation resistant materials (e.g. eddy-current sensors) and produced at low cost in large quantities (the critical range of motion is ~1 mm with resolution and repeatability of ~100 nm; and (2) custom integrated electronic circuits that can be ported to a radiation-hard process for use in an accelerator housing - specifically, circuits are needed for control of: beam position monitors; ion-pump controllers; low-level rf mixers, demodulators, multiplexers and digitizers; and magnet-mover controllers.

For this subtopic, further information on the first two paragraphs above can be obtained from John Cornuelle at SLAC (e-mail: johnc@SLAC.Stanford.EDU; phone: 650-926-2545; fax: 650-926-5124). For the third paragraph above, further information can be obtained from Andrei Seryi at SLAC (e-mail: seryi@SLAC.Stanford.EDU phone: 650-926-4805; fax: 650-926-5124). For the last paragraph, further information can be obtained from Ray Larson at SLAC (e-mail: larsen@SLAC.Stanford.EDU; phone: 650-926-4907; fax: 650-926-5124).

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* Available from National Technical Information Service. See Section 7.1.

24. HIGH ENERGY PHYSICS DETECTORS

The Department of Energy (DOE) supports research and development in a wide range of technologies essential to experiments in high energy physics and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification for use in high energy physics experiments or particle accelerators is desired. Principal areas of interest include particle detectors based on new techniques and technological developments (e.g., superconductivity or solid-state devices) or detectors that can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth), with particular interest in devices exhibiting insensitivity to very high radiation levels. Also of interest are novel experimental systems that use new detectors or use old ones in new ways that either extend basic high energy physics experimental research capabilities or result in less costly and less complex apparatus. Grant applications must clearly and specifically indicate their particular relevance to high energy physics programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Nonetheless, applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available at http://www.hep.net/sites/directories.html. **Grant applications are sought only in the following subtopics:**

Please note: ***(1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.***

a. Particle Detection and Identification Devices - Grant applications are sought for novel devices in the areas of charged and neutral particle detection and identification. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers and crystals or Cherenkov radiators), photosensitive detectors that could be used with light-emitting detectors (photomultipliers, micro-channel plates, photosensitive semiconductors), gas or liquid-filled chambers (used for particle tracking or in electromagnetic or hadronic calorimeters, Cherenkov or transition radiation detectors). The proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly (e.g., radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, cost).

b. Detector Support and Integration Components - High energy physics experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into high-energy physics experiments. The support components must be well matched to the detectors and possess some or all of the following features: low mass, high strength or stiffness, low intrinsic radioactivity, exceptionally high or exceptionally low thermal conductivity, and low cost. Grant applications are also sought for alignment and cooling systems.

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25. HIGH ENERGY PHYSICS DATA ACQUISITION AND PROCESSING

The Department of Energy supports the development of advanced electronics and computational technologies for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for high energy physics research. Areas of present interest include event triggering, data acquisition, scalable clustered computers systems, distributed collaborative infrastructure, distributed data management and analysis frameworks, and distributed software development useful to high energy physics experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future high energy physics programmatic activities.

Although particle physics detector instrumentation, data processing and analysis, and software development typically occur in large collaborative efforts at national particle accelerator centers, there are efforts where small businesses can make innovative and creative contributions to the further development of the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available by institution at http://www.hep.net/sites/directories.html. Grant applications which propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. High-Speed Electronic Instrumentation - Grant applications are sought to develop components, electronics, systems, and instrumentation modules as follows:

(1) Special purpose chips and devices are sought for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, controllers, and communications interface devices.

(2) Circuits and systems are sought for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, particle calorimeters, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters (>300 MHz), and time-to-amplitude converters. Compatibility with one of the widely used module interconnection standards (e.g., FASTBUS, or VMEbus) is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

(3) Advanced, high speed logic arrays and microprocessor systems are sought for fast event identification, event trigger generation, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used module interconnection standards (e.g., FASTBUS, or VMEbus).

(4) Much of the electronics instrumentation in use in high energy physics is packaged in one of the international module inter-connection standards (e.g., FASTBUS, or VMEbus). Therefore, grant applications are sought for modules that will provide capabilities not previously available, for substantial performance enhancement to existing types of modules, and for components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, interconnection systems, communication modules and systems, and disk-drive interface modules.

b. Large Scale Analysis Computer Systems - Grant applications are sought to develop: (1) computer system components and supporting software enabling large scale and open use of storage networks, especially for magnetic disks, optical disks, and magnetic tapes; (2) computer system components and supporting software enabling the use of TCP/IP protocols in a more efficient manner over a local area network; (3) computer software or systems for monitoring and operating heterogeneous computer systems and networks for functionality, performance, and manageability criteria (also, ease of software installation on hundreds of computers would be desired); (4) methods for integrating distributed authority and access control into distributed data systems; and/or (5) improvements to the quality, reliability and cost effectiveness of petabyte storage systems. Proposed efforts must address identified computing problems related to diverse, large scale computing systems that support particle physics analysis.

c. Distributed Collaborative Infrastructure and Distributed Data Management and Analysis Frameworks - Advanced computational tools and software are needed to strengthen the ability of dispersed particle physics researchers to collaborate and to address problems related to the acquisition, handling, storage, analysis, and visualization of large datasets by these distributed collaborations. Grant applications are sought to develop: (1) client-server frameworks and Web tools for creating collaborative environments, facilitating remote participation of detector experts at the data collection stage and allowing collaborators to remotely monitor experiments; (2) software project management tools; (3) computer system components and supporting software incorporating the use of Quality of Service features generally available in wide area networks; (4) portable systems to hold very large collections of data of the type created in connection with the operation of very large detectors, along with data management tools; (5) visualization and software environments appropriate for physics analysis; (6) software to support data systems distributed over a wide area network; (7) framework, interconnects, and other peripherals which allow the use and orderly aggregation of commodity computers and computer peripherals at larger than normal scales, or at higher performance levels than usual; and/or (8) software development tools for the production of computer software to meet identified problems related to distributed, large scale software development, configuration management, and data analysis. For (8), approaches of interest include distributed portable testing and Computer Aided Software Engineering (CASE), including configuration management tools for a portable, distributed environment; (9) Web tools for remote data selection ("skimming"); and (10) neural nets for optimization of data cuts and pattern recognition.

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***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

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PROGRAM AREA OVERVIEW
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The Office of Advanced Scientific Computing Research (ASCR) supports research in computational technology and laboratory technology research, subprograms that underlie a variety of Department of Energy missions.

ASCR's primary mission, carried out by the Mathematical, Information, and Computational Sciences subprogram, is to discover, develop, and deploy the computational and networking tools that enable researchers in the scientific disciplines to analyze, model, simulate, and predict complex phenomena important to the Department of Energy. To accomplish this mission the program fosters and supports fundamental research in advanced scientific computing - applied mathematics, computer science, and networking - and operates supercomputer, networking, and related facilities. The applied mathematics research efforts provide the fundamental mathematical methods to model complex physical and biological systems. The computer science research efforts enable scientists to efficiently run these models on the highest performance computers available and to store, manage, analyze, and visualize the massive amounts of data that result. The networking research provides the techniques to link the data producers; e.g., supercomputers and large experimental facilities with scientists who need access to the data. The two topics that follow support this scientific computing mission.

The Laboratory Technology Research subprogram funds high-risk, multidisciplinary research partnerships between the DOE's Office of Science multi-program national laboratories and private industry. Projects supported explore applications of basic research advances in the investigation of problems, over a full range of scientific disciplines, whose solutions have promising commercial potential.

26. HIGH PERFORMANCE NETWORKS

The Department of Energy (DOE) supports a wide range of research activities in mathematics, information, and computational sciences to support distributed high-end computing, remote instrumentation and data storage, and scientific collaboration in DOE. Many emerging energy research problems require coordinated access to distributed resources - people, data, computers, and facilities. These problems generate an enormous amount of data that must be remotely analyzed and visualized by scientists in geographically distributed scientific facilities. The distributed and dynamic character of this large-scale resource sharing calls for secure, high performance network infrastructures and services to support collaboration on a national and international scale. The current Internet, built with commodity components and optimized for low-speed, best-effort applications, lacks the capability and functionality to deliver the level of performance and security required by DOE scientific applications and collaborations. Therefore, research is needed to enhance the performance and capabilities of network services, transport protocols, network control and management, and other features that contribute to the overall security, survivability, and scalability of contemporary networks. Grant applications must clearly state how the proposed research will be beneficial to the long-term mission of DOE and at the same time make significant contributions to the general subject areas. **Grant applications are sought only in the following subtopics:**

a. Agile Optical Network Technologies - New technology is needed to harness and extend the unprecedented bandwidth capability offered by Dense Wave Division Multiplexing (DWDM) to the DOE high-performance computing and high-end scientific applications. Grant applications are sought to develop agile optical network technologies leading to the development and deployment of highly reconfigurable optical network components, optical routing and switching technologies, scalable link layer framing protocols, and optical interconnects for supercomputers and cluster computing. Areas of interest include: (1) scalable non-SONET (Synchronous Optical Networks) framing mechanism for Internet Protocol (IP) over DWDM at OC-192 (Optical Carrier level 192 (concatenated at 2.5 Gbps) rates and above; (2) optical interconnects for the interconnection of supercomputers, cluster computing hardware, and storage devices; (3) Multi Protocol Label Switching (MPLS) over dynamically reconfigurable lambda-switched networks; and (4) performance characterization of legacy protocols (Point-to-Point Protocol (PPP), High Data Link Control (HDLC), and Ethernet frames) operating over terabits/sec optical links. Grant applications must address optical network issues of specific interest to the DOE computing environment.

b. Resource Discovery and Sharing - Grant applications are sought for research and software tool development in technologies that support coordinated resource sharing in areas such as resource discovery, resource access, authentication, authorization, etc. Tools should be developed using an integrated services approach and may be, for example, robust full-featured servers with one to many services that incorporate best practice concepts emerging from the grid community.

c. Network Security - Grant applications are sought to develop tools and techniques for: (1) secure and fair means for enabling application and user access and control of network resources; (2) smart network management (i.e., highly capable network management agents, tools, and stations) that adapt to a dynamic network infrastructure; and (3) innovative techniques for intrusion detection using Artificial Intelligence (neural networks, fuzzy logic, etc.) and advanced statistical techniques. The tools and techniques must be applicable throughout the high speed network. Grant applications must address appropriate public key infrastructure (PKI) research that supports these efforts and that is interoperable and consistent with industry-driven and government PKI.

d. Network Engineering - Grant applications are sought to develop advanced tools, technology, and services to: (1) monitor, analyze, and manage multiple layers of heterogeneous networks; (2) perform effective and scalable routing/switching including best effort and priority traffic, reliable multicast, real time, and variable or flat accounting/costing mechanisms and protocols for differentiated services; (3) manage lead user infrastructure, which entails the dynamic and secure concurrent support of production and network research traffic (i.e., multiple policy traffic that may be in conflict with one another) on the same infrastructure, as well as the de-aggregation of tributaries; and (4) develop remote (wireless), reliable and secure network connectivity at higher speeds than currently commercially available for real time operation (to include two way videoconferencing, visualization, and collaboration) and capable of supporting a variety of protocols.

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***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

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27. HIGH PERFORMANCE SYSTEMS SOFTWARE

The Department of Energy (DOE) sponsors a wide range of research activities in mathematics, information, and computational sciences to support high-end computing that is required to solve leading edge scientific problems critical to DOE's missions. The solution of these problems requires hundreds of gigaflops to multiple teraflops of computing power. Currently available computer architectures are based on clusters of mid range symmetric multiprocessor nodes, built with commodity components and optimized for mid-range commercial or scientific applications. In order to achieve acceptable performance on large clusters where 1000s of processors must effectively work on a single application, significant specialized software is needed. Therefore, to enhance the performance and capabilities of these clusters, improvements are needed in operating systems, system management software, performance monitoring and improvement tools, data management software and visualization software.

Grant applications must clearly state how the proposed research will benefit DOE's long-term mission and at the same time make significant contributions to the general subject areas. In addition, grant applications must demonstrate that the proposed research is scalable to at least 1000s of processors. Priority will be given to technical approaches that build upon open source software and which support interoperability across all operating systems important to the high-end community, including both proprietary and open source systems. **Grant applications are sought only in the following subtopics:**

a. System Management Software - Cluster management encompasses a wide range of tasks such as configuring new nodes, monitoring the state of the system and rebooting when necessary, and upgrading and installing new software. System vendors have supplied management tools for their products, but clusters built by end users are typically administered with ad hoc tools that are particular for a given site. Research in large clusters has generally not focused on systems management approaches or techniques. Grant applications are sought for innovative ways to manage large clusters of commercial computers. Areas of interest include power and fault management, software configuration control across nodes, and hardware and software status monitoring.

In addition, current operating systems are not optimized for clusters with 100s to 1,000s of processors and may incorporate design elements that raise significant barriers to achieving high end user application performance. Therefore, grant applications also are sought to develop improved operating systems that are based on portable methodology and that enhance the delivery of high performance to end user scientific applications in a large cluster environment.

b. Performance Monitoring and Management Tools - An important barrier to the efficient use of large cluster systems is the inability, in present systems, to sustain more than a small fraction of peak performance on priority applications. In order to provide a higher percentage of peak performance to end users, research and development is needed to develop software and programming techniques for the more effective utilization of large cluster systems. Grant applications are sought to develop tools that will increase the ability of scientific users, writing software in Fortran, C, or C++, to monitor and improve the performance of their software. Examples of important issues include memory utilization, cache performance, identification of communications bottlenecks, and optimization of data layout.

c. Data Management Tools - Existing data management tools characteristically focus on the needs of business systems and are not fully responsive to the data management needs of the scientific community. Grant applications are sought to develop database management systems approaches for high throughput parallel I/O and complex queries of large scientific databases; for agent methodology for feature extraction and complex query operations; and for tools for user-driven and automatic clustering, reclustering, or replication of objects to maximize retrieval efficiency.

d. Visualization Tools - A new generation of scientific visualization tools are needed to effectively display voluminous and complex scientific datasets. Grant applications are sought for visualization tools that support vector/tensor field visualization in 3-D; for remote and collaborative visualization methods; for the characterization of simulation, experimental, and visualization errors/uncertainties; and for adaptive, multiresolution, parallel and scalable visualization algorithms.

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PROGRAM OVERVIEW - NUCLEAR PHYSICS

http://www.er.doe.gov/production/henp/nucphys.html

Nuclear physics research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which, in turn determine the essential physical characteristics of the universe. The primary mission of the Nuclear Physics program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research. Attendant upon this core mission are responsibilities to enlarge and diversify the nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the nation's economic base.

Nuclear physics research is carried out at national accelerator facilities and through university programs. The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) and the Bates Linear Accelerator at MIT allow detailed studies of how quarks and gluons bind together to make protons and neutrons. CEBAF is planning a future upgrade in which the electron beam energy is doubled from 6 to 12 GeV. The Relativistic Heavy Ion Collider (RHIC), now in operation at Brookhaven National Laboratory (BNL), will instantaneously form submicroscopic specimens of quark-gluon plasma by colliding gold nuclei, thus allowing a study of the primordial soup of quarks and gluons thought to make up the early universe. RHIC is planning a beam luminosity upgrade in the future; a new electron-ion collider is also being discussed. The nuclear physics program supports research and facility operations that are directed towards understanding the properties of nuclei at their limits of stability and of the fundamental properties of nucleons and neutrinos. This research is made possible with the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL), the Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL) and the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory (LBNL), which provide complementary facilities for stable and radioactive beams as well as a variety of species and energies. In addition, the operations of accelerators for in-house research programs at four universities (Yale University, Washington University, Texas A&M University, and Triangle Universities Nuclear Laboratory (TUNL) at Duke University) provide unique instrumentation with a special emphasis on training of students. The nuclear physics program also supports non-accelerator experiments, such as the Sudbury Neutrino Observatory (SNO) facility, constructed by a collaboration of Canadian, English and U.S. supported scientists, and which is now taking data on solar neutrino fluxes, and will provide the first results on the "appearance" of oscillations of electron neutrinos into another neutrino type. A proposed Rare Isotope Accelerator (RIA) facility, is being designed that would provide a way to explore the limits of nuclear existence. By producing and studying highly unstable nuclei that are now formed only in the stars, scientists could better understand stellar evolution and the origin of the elements.

Our ability to continue making a scientific impact to the general community relies heavily on the availability of cutting edge technology and advances in detector instrumentation, electronics, software and accelerator design. The technical topics that follow describe research and development opportunities in the equipment, techniques, and facilities that are needed to conduct and advance nuclear physics research at existing and future facilities.

28. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT

Large scale data storage and processing systems are needed to store, retrieve, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider and the Thomas Jefferson National Accelerator Facility. These data, produced at rates of 100 MB/sec or more, result in the annual production of data sets on the order of several hundred Terabytes (TB). Similar data management systems are required to support the needs for non-accelerator nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Data Handling and Distribution - Large scale data storage and access, as well as processing and distribution systems are required for the scientific programs being carried out at Nuclear Physics facilities across the nation. These facilities produce 100s of TB of data per year. Many 10s of TB of data per year are distributed to many institutions around the U.S. and other countries for analysis by the scientific collaborators. Grant applications are sought for (1) hardware and software techniques to improve the effectiveness and reduce costs of handling such large data volumes, (2) hardware and software techniques to improve the effectiveness of the computational and data grids [see reference 3 for these uses] and (3) novel approaches to data mining, automatic structuring of data and information, and facilitated information retrieval.

Projections of the cost of data storage media show that magnetic disk media will soon be competitive with magnetic tape for storing large volumes of data. However, the infrastructure costs of operating a petabyte disk storage system could be prohibitive with current technology that keeps all disk drives powered and spinning. A characteristic of nuclear physics datasets is that most of the data is accessed infrequently. Therefore, grant applications are sought for new techniques leading to petabyte-scale magnetic disk systems that have low cost and low power usage that scale linearly with the amount of data accessed rather than total storage capacity.

b. Maintenance of Scientific Databases - The legacy of nuclear physics research is the data produced. Large projects like RHIC, Gammasphere, or the Jefferson Laboratory produce unique data that may never be re-measured. Experience tells us that only a small portion of the data is ever analyzed and published. Typical large research projects focus on the experiment and data taking but not database preservation. Therefore, grant applications are sought to develop permanent archiving and Internet dissemination procedures for nuclear physics experiments

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29. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

The Nuclear Physics program of the Department of Energy (DOE) supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Research and development is desired that will advance fundamental accelerator technology and its applications, which are tailored to nuclear physics scientific research. Areas of interest include the basic technologies of the Brookhaven National Laboratory's superconducting Relativistic electron Heavy Ion Collider (RHIC) with energies up to 100 GeV/amu per beam, technologies associated with RHIC beam luminosity upgrades and the development of an electron-ion machine, superconducting radio frequency (srf) linear accelerators such as the electron machine at the Thomas Jefferson National Accelerator Facility (TJNAF), and development of devices and/or methods that would be useful in the generation of intense accelerated beams of radioactive isotopes related to the construction of a Rare Isotope Accelerator (RIA) facility. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. **Grant applications are sought only in the following subtopics:**

a. Materials and Components for Radio Frequency Devices - Grant applications are sought for research and development leading to improved or advanced superconducting and room temperature materials or components for radio frequency (rf) devices used in particle accelerators. Areas of interest include: (1) peripheral components such as ultra high vacuum seals, terminations, cryogenic radio frequency windows, and magnetostrictive cavity tuning mechanisms; (2) termination materials for use at 2 to 4 K, compatible with the ultra high vacuum and dust-free environment, and capable of absorbing microwaves efficiently from 2 to 90 Ghz; (3) methods to avoid inclusions in the superconducting material and contamination on the surface of the superconductor; (4) innovative designs for hermetically sealed refrigerators and other cryogenic equipment that simplify procedures and reduce costs associated with reparability and modification; and (5) development of simple, low-cost mechanical damping techniques, effective in the 10-300 Hz range at 2 Kelvin, to reduce both construction and operating costs of facilities through smaller systems.

Grant applications are also sought for the initial design, modeling, and development of a new 13 kW continuous wave klystron power source at 1497 MHz to drive accelerator superconducting cavities. Such a device is needed for the TJNAF energy upgrade, for example. The klystrons should be able to operate at a variety of power levels depending on the parameters of each superconducting cavity and on the energy delivered to the electron beams. Because each superconducting cavity may require a different power level of operation, the klystron should contain a perveance-determining electrode in the klystron gun to limit beam power dissipation when operating at less than full power. Also, because the klystrons will be part of an energy feedback system, they should operate about 10 percent below their saturated power levels to allow headroom for control by the feedback system; this situation requires good stability in the linear gain region of the klystron. Klystron power efficiency is of major importance in all these modes of operation. Permanent magnet focusing of this new klystron design is desirable, but electro-magnet focusing would also be acceptable if better rf stability and operating efficiency obtains. Efficiencies greater than 55 percent are desirable for rf to beam power.

b. Design and Operation of Radio Frequency Beam Acceleration Systems - Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for heavy-ion accelerators. Areas of interest include: (1) superconducting and conventional continuous wave structures for the pre-acceleration of radioactive beams, which can operate in the velocity regime between 0.001 and 0.01 times the velocity of light, for ions with charge-to-mass ratios between 1/30 and 1/240; (2) superconducting rf accelerating structures appropriate for RIA drivers which can operate in segments of the range from approximately 0.1 to 0.8 the velocity of light; (3) the economical fabrication of many-celled rf cavities that still provide moderate damping of all higher-order modes; (4) improved techniques for phase stabilization of low velocity ion acceleration structures; (5) improvements to accelerating gradients and quality factor (Q) in cavities for both continuous wave (cw) and pulsed operation; (6) high duty factor, high power rf systems for radio frequency quadrupoles and linacs; and (7) techniques for coupling rf power into superconducting cavities operating at 2 K.

Grant applications are also sought to develop concepts and designs to improve the stability and performance of high efficiency, high brightness, electron linear accelerator systems. Areas of interest include energy recovery systems that preserve beam quality by thoroughly treating higher order modes and beam break-up phenomena, electron cooling for high-energy ion beams (e.g. RHIC (Relativistic Heavy Ion Collider (luminosity upgrade) and electron-ion collisions (e.g. electron collider with RHIC, or eRHIC), and increasing the threshold of multi-bunch, multi-pass beam breakup in energy-recovering electron linear accelerators. Grant applications must address not only beam dynamics but also the engineering issues of such systems by developing system and component level engineering requirements and associated conceptual designs.

Lastly, power requirements could be significantly reduced if

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the 5 kW, 1500 MHz cw klystrons, currently available for use at nuclear physics accelerator facilities, could be replaced by alternative technology. Grant applications are therefore sought for the design and development of high power solid state devices or other techniques, which would allow for significant reductions in accelerator power usage. The gain should exceed 30 dB and devices should exhibit long life, cost effectiveness, reliability, and high electrical efficiency.

c. Particle Beam Sources and Techniques - Grant applications are sought to develop: (1) particle beam ion sources with improved intensity, emittance, and range of species (areas of interest include high-charge-state sources for heavy ions, sources for negative and light ions, and polarized sources for hydrogen ions and electrons); (2) ion sources for radioactive beams (emphasizing high efficiency, high-charge-state ions, high temperature operation for coupling to high temperature production targets, and element selectivity; e.g., through the use of laser ionization); (3) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (4) methods to increase the charge state of ion beams (e.g., by the use of special electron-cyclotron-resonance ionizers or special stripping techniques); (5) power supplies to drive these sources; (6) high brightness electron beam sources utilizing continuous wave superconducting rf cavities with integral photocathodes operating at high acceleration gradients; and (7) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes in the presence of work function lowering material (i.e., cesium) in order to enhance the performance of photoemission electron sources.

Grant applications are also sought to develop target materials for radioactive beam production. These targets must be capable of use with beams of protons, neutrons, or heavy ions, with beam power of 10-100 kW, and must be configured for rapid release of isotopes and permit close coupling to an ion source to generate high intensity radioactive beams.

d. Accelerator Control and Diagnostics - Grant applications are sought for: (1) "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research (developments that offer generic solutions to problems in the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning are especially encouraged); (2) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy (including such advanced methods as neural networks or expert systems and techniques that are nondestructive to the beams being monitored); (3) beam diagnostic devices that have increased sensitivities through the use of superconducting components, such as filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices; (4) measurements of direct current, charged particle, average beam currents in the range 0.1 to 100 ?A with very high precision ($<10^{-4}$); and (5) low current beam diagnostics for radioactive ion beams (for exotic nuclei that will only be available as beams with intensities less than 10^7 nuclei/second (with such low beam intensities, it is very difficult to use standard beam diagnostic methods).

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30. NUCLEAR PHYSICS DETECTORS, INSTRUMENTATION AND TECHNIQUES

The Department of Energy (DOE) is interested in supporting projects that may lead to advances in target and detection systems for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art and outside the usual scope of research and development activities at the nuclear physics national accelerator facilities and university programs. In addition, a new suite of next-generation detectors will be needed for the proposed Rare Isotope Accelerator, the energy upgrade at TJNAF, the luminosity upgrade at RHIC, and the electron-ion accelerator. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Particle Detector Technology - Nuclear physics research has a need for devices for detecting and analyzing charged particles, neutrons, photons, and single atoms. These devices include: solid-state devices such as silicon strip and silicon drift detectors; photosensitive devices such as photodiodes, avalanche photodiodes, hybrid photomultiplier devices, single and multi anode photomultiplier tubes, and other novel photon detectors; detectors utilizing photocathodes for Cherenkov and UV light detection, and the development of new types of large area photoemissive materials such as solid, liquid, or gas photocathodes; micro-channel plates; gas-filled detectors such as proportional, drift, streamer, Cherenkov, micro-strip, gas electron multiplier detectors, resistive plate chambers, and straw drift tube chambers; liquid argon and xenon ionization chambers; single-atom detectors using laser techniques and electromagnetic traps; particle polarization detectors; magnetic spectrometer components and systems; electromagnetic and hadronic calorimeters; and position-sensitive segmented germanium detectors. Grant applications are sought to develop advancements in detector technology for all of the above-mentioned detectors.

With respect to solid state tracking devices, particularly silicon drift, strip, and pixel detectors, grant applications are sought for: (1) manufacturing techniques, including interconnection technologies, for high granularity, high resolution, light-weight, and radiation-hard solid state devices; (2) highly arrayed solid state detectors for neutron detection, with integrated electronics to read-out pulse height. (for example, silicon strip or pixel arrays with integrated electronics and coating could be developed so that an alpha-particle is produced when hit with a thermal or cold neutron - the alpha-particle would recoil into the silicon for measurement resulting in an inexpensive, large acceptance, high rate device); (3) thicker (more than one mm) segmented silicon charged particle and x-ray detectors and associated high density, high resolution electronics; and (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2.

With respect to position sensitive particle tracking devices, grant applications are sought for: (1) position sensitive, high resolution, germanium gamma-ray detectors (determining the exact position, within a few millimeters, and energy of individual interactions of gamma-rays in germanium detectors, and allowing for the reconstruction of the energy and path of individual gamma-rays using tracking techniques); (2) alternative materials, with the same resolution as germanium for gamma-ray detection, but with significantly higher efficiency and relatively higher temperature operation (in order to overcome the costly and bulky requirement to cool germanium detectors to liquid nitrogen temperatures - this would allow for new detector applications in nuclear physics, medical imaging, etc.); (3) advances in more conventional tracking detector systems, such as drift chambers, pad chambers, time expansion chambers, and time proportional chambers (areas of interest include improved gases or gas additives - that resist aging, improve detector resolution, decrease flammability, and offer larger/more uniform drift velocity - for these chambers, and the development of innovative trackers for RHIC and CEBAF physics such as a fiber optic tracking device).

With respect to particle identification detectors, grant applications are sought for: (1) inexpensive, large-area, high-quality Cherenkov materials; (2) inexpensive, position sensitive large-sized photomultiplier tubes for Cherenkov counters; (3) affordable methods for the large volume production of xenon and krypton gas (which would contribute to the development of transition radiation detectors and would also have many applications in X-ray detectors); and (4) very high resolution particle detectors or bolometers based on semiconductor materials and cryogenic techniques.

Grant applications are also sought for new detector materials for high resolution, light charged particle detectors, capable of measuring energies of alpha particles and protons with less than 5 keV resolution. This would allow spectroscopy experiments using light charged particles to be performed in the same way as gamma spectroscopy, enabling a deeper understanding of nuclear excitations not currently possible with gamma-ray spectroscopy.

b. Scintillators and Associated Materials - Grant applications are sought to develop new materials or advancements for: (1) scintillator materials for high resolution X-ray detectors (CdZeTe, AlSb, etc.); (2) plastic scintillators, fibers, and wavelength shifters; (3) cryogenic liquid scintillation gamma ray detectors (LXe); (3) Cherenkov radiator materials with indices of refraction up to 1.10 or greater with good optical transparency; and (4) stable calorimeter materials in single block lengths (up to 20 radiation lengths) which could be produced in large quantities and at low cost; and composite materials with high radiation resistance.

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Grant applications are also sought for new scintillation materials for use in large intermediate-energy photon detector arrays. These materials must exhibit a light output comparable or greater than bismuth germinate, have a fast decay time (in the range from less than one nanosecond to a few tens of nanoseconds) with no slow component, be useful for high rate and/or time of flight applications, have their density and mean nuclear charge be such that the radiation length is less than 2 cm, and be capable of fabrication in large pieces (up to 20 radiation lengths) at reasonable costs.

c. Nuclear Targets - Grant applications are sought for the development of special nuclear targets, which specifically and explicitly address nuclear physic s research needs. These special targets include: polarized (with nuclear spins aligned) high-density gas or solid targets; windowless gas targets and supersonic jet targets, for use with very low energy charged particle beams; and liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low emittance charged particle beams are used. There is also interest in new technology for the production of ultra-thin films for targets, strippers, and detector windows.

d. Adhesives - Grant applications are sought to develop special epoxies that could improve the assembly of detectors used in nuclear physics. Of particular interest is an adhesive that can be applied to pieces in a fixture but does not set until an external stimulus is applied (analogous to UV epoxies that cure upon the addition of UV light, except that, in this case, the epoxy is not exposed once the pieces to be glued are assembled in a fixture).

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Please note: ***(1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.***

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31. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

The DOE seeks developments in detector instrumentation electronics with improved energy, position and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, and background suppression. Of particular interest is innovative readout electronics for use with the nuclear physics detectors described in Topic 30. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Digital Electronics - Digital signal processing electronics is needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: (1) digital processors that include the features of current main amplifiers, such as pile-up rejection and ballistic deficit correction; (2) digital pulse processing electronics for solid state detectors, in particular for position sensitive detectors; and (3) fast digital processing electronics in order to determine the position of interaction points (of particle collisions) to an accuracy smaller than the size of the detector segments (note that it will be important to analyze the pulse shape of the preamplifier pulses).

b. Integrated Circuits - Grant applications are sought for special purpose, custom designed integrated circuits and for circuits and systems for rapidly processing data from highly segmented, position-sensitive germanium detectors (pixel sizes of approximately 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include (1) representative circuits such as low noise preamplifiers, amplifiers, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) readout electronics for solid-state pixilated detectors, including interconnection technologies and amplifier/sample and hold integrated circuits; and (3) a constant fraction discriminator that has uniform response for low and high

energy gamma-rays, as well as a discriminator that can separate neutrons and gamma rays. These circuits should be fast, low-cost, high-density, and configurable in software for thresholds, gains, etc. Compatibility with one of the widely used module interconnection standards (FASTBUS, VMEbus, etc.) would also be highly desirable, as would low power consumption, advanced packaging, adaptability to a large number of multiple channels, and commercial digitizing circuits (ICs, ADCs, FADCs, and TDCs) made available as multi-channel chips (4X, 8X, 16X ...).
In addition, planned luminosity upgrades at RHIC and experiments at the Large Hadron Collider will require fine-grained vertex and tracking detector (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low noise amplification and processing of detector signals and that are suitable for these next generation detectors. The microelectronics and associated interconnections will need to be lightweight and have low power dissipation. Designs that minimize higher gate leakage currents due to tunneling and maintain dynamic range would be of particular interest.

c. Advanced Devices and Systems - Grant applications are sought for improved or advanced devices and systems used in conjunction with the electronic circuits and systems described in subtopics a and b. Areas of interest include bus systems, data links, event handlers, multiple processors, and fast buffered time and analog digitizers. Generalized software and hardware packages, with improved graphic and visualization capabilities, for the acquisition and analysis of nuclear physics research data are also of interest.

d. Manufacturing Techniques - Grant applications are sought to develop: (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes with dimensions from 2m x 2m to 5m x 5m and 100-200 micron thick (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes in a reliable, robust way to large rolls of metallized mylar or kapton (this would have applications in detectors such as time expansion chambers or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard interdensity connectors.

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PROGRAM AREA OVERVIEW
OFFICE OF FUSION ENERGY SCIENCES

http://wwwofe.er.doe.gov

The Department of Energy is funding fusion science and technology research as a valuable investment in the clean energy future of this country and the world, as well as to sustain a field of scientific research - plasma physics - that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The mission of the Fusion Energy Sciences (FES) program is to acquire the knowledge base needed for an economically and environmentally attractive fusion energy source. FES research efforts seek to: (1) understand the physics of plasmas, the fourth state of matter - plasmas constitute most of the visible universe, both stellar and interstellar, and progress in plasma physics has been the prime engine driving progress in fusion research; (2) identify and explore innovative and cost-effective development paths to fusion energy - the current fusion program encourages research on a wide range of approaches, including the tokamak, the leading power plant candidate, other magnetic configurations, and inertial fusion energy using particle beams or lasers; and (3) explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in a international effort - reducing costs, avoiding duplication of efforts, and bringing the best available scientific and engineering talent together to seek solutions to complex problems can best be done through the cooperative efforts of the world fusion community.

This is a time of important progress and discovery in fusion research. The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants, and encouraging private sector interests to apply concepts developed in the fusion research program. It is felt that small businesses, by performing research within the following technical topics, can make significant contributions to these efforts. This solicitation is restricted to science and technology relevant to magnetically confined plasmas and inertial fusion energy. Grant applications pertaining to cold fusion will be declined, as will those related to other fusion energy concepts not based specifically on the use of plasmas for purposes of producing energy/electricity for non-defense purposes.

32. FUSION SCIENCE AND TECHNOLOGY

The Fusion Energy Sciences program currently supports several fusion experiments with many common objectives. These include expanding the scientific understanding of plasma behavior and improving the performance of high temperature plasma for eventual energy production. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for measuring magnetic plasma parameters, for plasma processing, and for magnetic plasma simulation, control, and data analysis. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. **Grant applications are sought only in the following subtopics:**

a. Diagnostics for Magnetic Fusion Plasma Research - Grant applications are sought to develop measurement techniques for parameters such as plasma density, electron and ion temperature, plasma current and current density, plasma position and shape, impurity density, magnetic field strength, ambipolar potentials, and radiation from the plasma. Diagnostics suitable for experimental devices using relatively low magnetic fields or burning plasmas are of particular interest. New diagnostics for measurements in the 3-dimensional plasmas characteristic of stellarators are also needed. In addition, methods are desired for examining the edge and divertor regions in tokamak plasmas. Both new techniques and methods to improve the accuracy and resolution of existing diagnostics (e.g., improving the signal-to-noise ratio or extending the range of measured

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parameters) will be considered. Measurements must be both spatially and temporally resolved for both the absolute values of parameters and for small relative differences. For some of the above parameters, real-time measurements will be an advantage in order to provide for plasma control. For the DIII-D experimental program at General Atomics, diagnostics are needed for: (1) fluctuations of electron and ion temperatures, electron density and electric field, particularly in the high density plasma core (fluctuation frequencies are typically in the range of 100 KHz to several MHz, and fluctuation levels are typically less than 1 percent of the quasi-steady-state plasma levels); (2) transport due to fluctuations, which requires cross-correlations between density, temperature and velocity fluctuations; (3) visualization of turbulence in two dimensions, or even three dimensions; and (4) imaging of non-thermal electrons in two dimensions, with energy resolution if possible. For additional information, see the summary of the February 1998 workshop addressing measurement needs in magnetic fusion devices, listed as one of the references.

Grant applications are also sought to apply diagnostics technology, developed for fusion energy, to the use of plasmas in manufacturing. These grant applications should show how the application of these diagnostics would contribute to the understanding of plasmas used in manufacturing, as well as provide an improved basis for modeling these plasmas.

b. Components for the Generation, Transmission, and Launching of High Power Electromagnetic Waves - Tools are needed to support fusion experimental research in such areas as plasma heating and temperature profile control. Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of ion cyclotron resonance heating (50 to 300 MHz), lower hybrid resonance heating (2 to 20 GHz), and electron cyclotron resonance heating (100 to 300 GHz). Components of interests include: power supplies, antenna and launching systems, tuning and matching systems, unidirectional couplers, mode convertors, windows, output couplers, loads, and diagnostics to evaluate the performance of these components, fault protection devices and energy extraction systems from spent electron beams.

c. Plasma Simulation and Data Analysis - The simulation of fusion plasmas is important to the development of plasma discharge feedback and control techniques. The simulations can be used to make reliable predictions of the performance of proposed feedback and control schemes and to identify those that should be tested experimentally. However, accurate simulations of fusion plasmas are very difficult because of the enormous range of temporal and spatial scales involved in plasma behavior. Considerable progress has been made in recent years in understanding and simulating plasma turbulence along with associated transport, macroscopic equilibrium and stability, and the behavior of the edge plasma. However, there remains a need to integrate the various plasma models. Grant applications are sought to develop computer algorithms applicable to plasma simulations that account for an expanded number of plasma features and an integration of plasma models. Some examples of possible approaches include algorithms that incorporate mathematical techniques such as neural networks, sparse linear solvers, and adaptive meshes; algorithms for coupling disparate time and space scales; efficient methods for facilitating comparison of simulation results with experimental data; and visualization tools for local and remote analysis and presentation of multi-dimensional time dependent data.

Grant applications are also sought to develop software tools useful for the analysis and distribution of fusion data. Areas of interest include methods for coupling codes across architectures and through the Internet; techniques for making highly configurable scientific codes; data management and analysis techniques for large data sets; and remote collaboration tools that enhance the ability of a geographically distributed group of scientists to interact in real-time.
The computer algorithms and programming tools should be developed using modern software techniques and should be based on the best available models of plasma behavior.

d. Superconducting Magnets and Materials - New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems; i.e., high field magnets (12 to 20 T) and low loss pulsed magnets. Grant applications are sought for: (1) innovative and advanced materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs; (2) cryogenic superconductor materials with high critical current density, low sensitivity to strain degradation effects, and radiation resistance; (3) novel, low-cost cable designs and fabrication techniques, which minimize conductor strain; (4) superconducting joints for high field and pulsed applications; (5) novel, advanced sensors and instrumentation for non-invasively monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); (6) thick (15-30 cm) weldable structural case materials with high strength and toughness at 4 K; (7) welding techniques for such thick cryogenic structural materials; and (8) radiation-resistant electrical insulators (e.g., wrapable inorganic insulators and low viscosity organic insulators, which exhibit low outgassing under irradiation).

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33. HEAT REMOVAL IN FUSION SYSTEMS

An attractive fusion energy source will require the development of materials and technologies to withstand the high levels of surface heat flux and neutron wall loads expected for the in-vessel components of future fusion energy systems. Plasma facing materials must be developed that can perform under harsh environmental conditions including high heat and particle flux, high temperatures, and plasma-induced erosion, as well as neutron irradiation from burning plasmas. In addition, innovative in-vessel concepts will be required for the removal of heat at high power densities. **Grant applications are sought only in the following areas:**

a. Solid Surface Plasma Facing Materials and Technologies - Grant applications are sought for: (1) improved refractory metals (preferably tungsten, but molybdenum, niobium, zirconium, vanadium and titanium will be considered) where neutron radiation resistance, thermal conductivity, and/or thermal fatigue resistance are increased; (2) novel surface geometries to increase heat flux limits and/or fatigue life; (3) techniques to enhance heat transfer and heat flux limits for water, helium, or liquid metal coolants; (4) joining techniques for refractory metals for use up to 1200?C; (5) non-destructive evaluation techniques for armor joints and critical heat flux monitoring; and (6) innovative fabrication techniques that improve performance and reliability while reducing complexity and/or cost. All materials and components proposed must be able to withstand surface heating conditions, which include long pulse (tens of seconds to steady state) heat fluxes for first wall components (up to 2 MW/m^2) and for limiter and divertor components (up to 50 MW/m^2) for up to one million cycles. In addition, materials and components that are capable of accommodating short pulse (about one thousandth of a second) heat fluxes on surfaces subjected to plasma disruptions (10 to 500 MW/m^2) are of particular interest. Water and helium gas are the coolants of primary interest. Grant applications must clearly identify proposed materials and configurations and include preliminary analysis to indicate the potential for achieving the performance capabilities sought, including maximum and minimum temperatures of key materials. Grant applications pertaining to the use of liquid surfaces, carbon or graphite based materials and composites, or the use of silicon carbide composites are not of interest for this subtopic and will be declined.

b. Liquid Surface Particle and Heat Removal in Fusion Systems - Innovative liquid surface concepts are desired for heat removal from surface heat fluxes at first walls and divertors of about 2 MW/m^2 and 50 MW/m^2, respectively, with good safety, reliability, and maintenance features. Current interests are focused on evaluating the use of flowing liquid metals, with direct exposure to the plasma, which can potentially remove particles as well as surface heat. Candidate liquids metals include lithium, tin-lithium, tin, gallium, and lead-lithium. Also, lithium-beryllium-fluoride salts are of interest for surface heat fluxes up to 2 MW/m^2. Grant applications are sought to develop: (1) techniques for the removal first wall and divertor heat loads by free surface flowing liquids (proposed techniques should address the effect of magnetohydrodynamics on heat transfer and should also consider heat removal enhancement techniques, such as turbulence promoters); (2) efficient nonlinear solution methods, as well as alternate object-oriented languages for computational tools, to model fusion-relevant issues of liquid wall flows, such as heat transfer at free surfaces and free flows with magnetohydrodynamic effects and turbulence; (3) techniques, such as the addition of alloying materials, to improve the plasma compatibility of liquid surfaces; (4) nozzles for liquid injection (e.g., streams, jets, films, and droplets) and collection/removal techniques that are drip and splash free, self-cooling, and efficient in head recovery at the outlet; (5) non-invasive diagnostics for experiments to study high temperature free surface liquid flows in magnetic fields (such diagnostics might include measurements of mean flow velocity, turbulence intensity, velocity fluctuations, flow depth, and surface/depth temperature profiles); (6) efficient techniques for pumping liquid metals in the presence of a magnetic field, including the production of free surface flows; and (7) techniques for validation of fluid flow and heat transfer models.

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Argonne National Laboratory
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34. INERTIAL FUSION ENERGY

Inertial fusion energy is produced by ignition and burn of an energy-producing target. Conditions necessary for ignition and burn result from the external application of energy to the fuel target by an external driver. Although several drivers such as lasers and ion beams have been considered, the emphasis in the fusion energy science program is on intense heavy ion beams as drivers. These beams are produced by induction linear accelerators with components to produce, accelerate, transport, and focus beams of required energy and intensity. The Fusion Energy Sciences program in inertial fusion energy supports research and technology in the generation, transport, and measurement of these heavy ion beams. There is also interest in selected technology topics with relevance to different inertial fusion energy driver concepts. **Grant applications are sought only in the following subtopics:**

a. Diagnostics for Heavy-Ion-Beam-Driven Inertial Fusion Research - Grant applications are sought to develop instrumentation and time-resolved measurement techniques of high charge-density heavy-ion beams of energy greater than 0.5 MeV and radius ~1 to 5 cm. Beam parameters of interest include current, density distribution, beam position, energy, energy distribution, emittance, and space potential, in Injector, Transport, and Final Focus sections. Of particular interest are innovative non-intercepting position detectors and optical (including scintillator-based) beam diagnostics suitable for rapid characterization of beams in both the present (0.5 to 2 MeV) and higher energy range, and diagnostics for characterizing trapped secondary electron distributions. Further information may be obtained in the HIF Symposia series [see reference for 12th International Symposium].

b. Beam Generation and Transport - Grant applications are sought for the development of high current, high brightness ion sources for heavy ion induction linacs that can produce beam currents >0.5 A with <1 p mm-mrad emittance and short pulse lengths ~ 1 ?sec, and that can be extended to compact arrays of multiple beams. Grant applications are also sought for advanced enabling technology to produce arrays of small superconducting quadrupoles for multiple beam transport. The quadrapoles should be designed to address problems associated with channel vacuum pumping, vacuum dewars, and cryogenic leads in a compact and cost effective manner.

c. Models for Electron Production in Accelerators for Heavy-Ion Beam-Driven Fusion - Grant applications are sought for computational modules to calculate cross-sections for the production of neutrals, ions, and electrons via wall bombardment by beam ions and other species, source distribution functions for the resultant products, cross sections for ionization and charge-exchange of the neutrals by the ion beam, and the volumetric evolution of neutral gas. Grant applications are also sought for the development of a set of subroutines suitable for straightforward inclusion into existing intense-beam simulation codes (such as WARP, BEST, and/or LSP). Initial calculations using these models should be carried out in a regime relevant to the upcoming High Current Experiments at Lawrence Berkeley National Laboratory (LBNL). The models should be sufficiently general that they can be applied to a wide variety of ion accelerators for a broad range of applications.

d. Technology for Inertial Fusion Energy (IFE) - In an inertial fusion power plant, targets must be repetitively injected into a reactor chamber and driven by either a heavy ion beam, a high power laser, or a pulsed power machine (z-pinch or magnetized target fusion). The targets must be fabricated and injected with great precision. Moreover, the target releases a high intensity burst of neutrons, energetic particles, and x-rays that must be contained within the chamber. Grant applications are sought to develop:

(1) Damage resistant chamber materials. The x-rays, neutrons, and particle debris released in inertial fusion have energies up to several MJ/m^2 and are emitted on a time scale from 1 ns to 100 microseconds. Wall materials must survive this environment for periods of up to several years at repetition rates up to 10 Hz. The wall materials must provide low radioactivity under neutron exposure and high temperature operation consistent with efficient power production. Schemes that can protect or shield the first wall are also of interest.

(2) Damage resistant laser optics and optics protection methods for the last optical element before the reactor chamber in a laser fusion system. Both metal mirrors and fused silica windows have been proposed for this "final optic," but other technologies may be appropriate. The final optic must operate at 1/4 to 1/3 micron wavelength and must be protected from exposure or capable of withstanding pulsed irradiation by neutrons, x-rays, and debris. In either approach, the optical elements must survive for several years.

(3) Low-cost fabrication methods for mass-produced inertial fusion energy targets, including targets filled with deuterium-tritium fuel and coated with a protective layer. In an IFE power plant, about 500,000 cryogenic targets must be prepared and injected each day at a rate of 5-10 Hz into a target chamber operating at elevated temperatures. These targets must be precisely made and cost less than $0.30 each.

(4) Methods for target injection and tracking. Targets driven by heavy ion or laser beams must be injected into the chamber at a rate of 5-10 Hz, at velocities from 200 to 400 m/s, and with an acceleration approaching 1000 g. The targets also must be tracked precisely inside the chamber. Gas guns, electrostatic accelerators and electromagnetic accelerators are being evaluated as candidate target injectors. Techniques to accurately track the target (in order to steer them or the driver beams) also are needed.

(5) Efficient procedures for the repetitive replacement of recyclable transmission line (RTL), target assembly, and close-packed coolant. For pulsed-power drivers (z-pinch and magnetized target fusion), the RTL, target assembly, and close-packed coolant (for shock mitigation) must be repetitively replaced on a relatively slow time scale (about 0.1 Hz).

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PROGRAM AREA OVERVIEW - NUCLEAR ENERGY, SCIENCE AND TECHNOLOGY

http://www.nuclear.gov
http://www.ne.doe.gov

Continued use of nuclear power is an important part of the Department's strategy to provide for the Nation's energy security, as well as to be responsible stewards of the environment. Nuclear energy research currently provides over 20 percent of the U.S. electricity generation and will continue to provide a significant portion of U.S. electrical energy production for many years to come. Also, nuclear power in the U.S. makes a significant contribution to lowering the emission of gases associated with global climate change and air pollution.

The Office of Nuclear Energy, Science and Technology (NE) enables the Department of Energy to provide the technical leadership necessary to address critical domestic and international nuclear issues by administering research and development and technical assistance in the following general areas: (1) the Nuclear Energy Research Initiative (NERI) Program addresses key issues affecting the future of nuclear energy in order to preserve U.S. nuclear science and technology leadership, (2) the Radioisotope Power Systems Program develops new state-of-the-art radioisotope power systems to support the NASA space missions and terrestrial applications for other agencies, (3) the Nuclear Energy Plant Optimization (NEPO) Program conducts research to assure the continued safe and reliable operations of over 100 of the Nation's nuclear power plants, (4) the University Reactor Fuel and Educational Assistance Program is designed to help retain the U.S. nuclear engineering capability for conducting nuclear research, addressing pressing nuclear environmental challenges, and preserving the nuclear energy option, and (5) the Isotope Production Program produces and sells hundreds of stable and radioactive isotopes that are widely used by domestic and international customers for medicine , industry and research applications.

35. ADVANCED TECHNOLOGIES FOR NUCLEAR ENERGY

Nuclear power provides over 20 percent of the U.S. electricity supply without emitting harmful air pollutants, including those that may cause adverse global climite changes. New methods and technologies are needed to address key issues that affect the future deployment of nuclear energy and to preserve the U.S. leadership in nuclear technology and engineering. This topic addresses several of these key technology areas: improvements in nuclear reactor technology, computer simulation and modeling applications, and advanced thermoelectric conversion devices and materials for improved radioisotope power systems. **Grant applications are sought only in the following subtopics:**

a. New Technology for Improved Nuclear Energy Systems - Improvements and advances are needed for reactor systems and component technologies that would be ultimately used in the design, construction, or operation of existing and future nuclear power plants and Generation IV nuclear power systems [See References 1-3]. Grant applications are sought to (1) improve and optimize nuclear power plant, systems, and component instrumentation and control, by developing advanced instrumentation, sensors, controls, and more accurate measurement of key reactor and plant parameters; (2) improve monitoring of plant equipment performance and aging, using improved diagnostic techniques for in-service and non-destructive examinations; and (3) improve corrosion resistance for light water reactor coolant system components, secondary side equipment, and balance of plant systems, by exploring advancements in materials and chemistry control systems [See Reference 4]. Grant applications that address concepts for complete or partial reactor plant design are not of interest and will be declined.

b. Advanced Reactor Computer Simulation and Modeling Applications - Advanced computational techniques are needed for the design, development, testing, monitoring, and safety evaluation of currently existing nuclear power plants as well as advanced reactor designs and Generation IV nuclear power systems [See References 1-3]. Grant applications are sought for new computer simulation software and modeling applications, including those that use parallel processing techniques, to support one or more of following areas: (1) design, development, safety evaluation methods, and engineering calculations for new and existing nuclear reactors, major reactor components, and reactor core and fuel assemblies; and (2) assessment, measurement, instrumentation, and control of nuclear reactor plant performance and operations. Grant applications that address concepts for complete or partial reactor plant design are not of interest and will be declined.

c. Conversion Devices and Materials for Improved Performance of Radioisotope Power Systems - Radioisotope Thermoelectric Generators (RTG) have been the sole electrical power systems employed for NASA deep space exploration missions such as Voyager 1 and 2, Galileo, Ulysses and more recently Cassini [See References 1, 5-7]. These power systems provide units of power equal to nominally 100 -150 watts electrical. The RTG provide very long life reliability, but their conversion efficiencies are low, typically 6.5 to 7.5 percent when the silicon-germanium (SiGe) unicouple is used as the thermoelectric conversion device. Because of changes in mission plans and philosophy, future NASA requirements will include higher conversion-efficiency units with power levels from 50 to about 200 watts in planetary surface and deep space vacuum environments. In anticipation of these future needs, grant applications are sought to:

(1) Identify and demonstrate a selective vent material for Radioisotope Power System (RPS) generator housings which will allow helium to escape but will prevent air (oxygen, nitrogen) and carbon dioxide from entering the generator at various housing temperatures, up to 200?C;

(2) Develop separator materials for use in close-spaced thermoelectric modules for one of the following thermoelectric elements: PbTe/TAGS (TAGS is derived from the names of the major constituents - tellurium, antimony, germanium, and silver) at a hot-side temperature of 550?C or SiGe at a hot-side temperature of 1000?C. (The ideal separator shall have a low thermal conductivity, be an electrical insulator, prevent diffusion of dopant materials, and limit mass transfer of thermoelectric materials over long operating lifetimes of the thermoelectric modules.);

(3) Develop a thermal "switch" material or device to prevent over-heating of the radioisotope heat source in the event normal heat flow through the energy conversion device (e.g.,

a Stirling converter) is lost; and /or

(4) Develop a high conductivity, low weight technique to collect heat from a GPHS (general purpose heating device) module (~3.866" x 3.92") and conduct it into the cylindrical heater head of a Stirling converter (2" diam x 0.5" wide) at a temperature of 650?C.

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PROGRAM AREA OVERVIEW
DEFENSE NUCLEAR NONPROLIFERATION

http://www.nn.doe.gov

The worldwide proliferation of Weapons of Mass Destruction (WMD) and their missile delivery systems is one of the most serious dangers confronting the United States. This danger is continuing, with far-reaching consequences for international security and stability. Based on the highly specialized scientific, technical, analytical, and operational capabilities of the Department and its National Laboratories, the Department of Energy (DOE), through its Office of Defense Nuclear Nonproliferation (NN), is uniquely suited to provide leadership in national and international efforts to reduce the danger to U.S. national security posed by WMD. Within NN, the Office of Nonproliferation Research and Engineering conducts applied research, development, testing, and evaluation (and leverages the work of others (to produce technologies that lead to prototype demonstrations and resultant detection systems, thereby strengthening the U.S. response to current and projected threats to national security and world peace posed by the proliferation of nuclear, chemical, and biological weapons, and the diversion of special nuclear material. Specific objectives include developing technologies for: (1) remote detection of the early stages of a proliferant's nuclear weapons program; (2) location, identification, and characterization of nuclear explosions underground, underwater, in the atmosphere, and in space, to enhance the U.S. nuclear explosion monitoring capability; (3) nuclear materials protection, control and accounting; monitoring nuclear arms control agreements; and detecting the movement of nuclear materials; (4) and detecting the proliferation or use of chemical and biological agents, and minimizing their consequences. Developed technologies are transitioned to other government users or are directly commercialized.

***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

Small businesses that submit grant applications under the following topics are encouraged to collaborate (formally or informally) with DOE national laboratories. Where necessary, collaborations may be arranged after awards are made. The objective is to help the small businesses get a better understanding of DOE's requirements and to help integrate each company with the potential DOE-related users of the technology.

36. SENSOR TECHNOLOGY FOR DETECTING THE PROLIFERATION OF WEAPONS OF MASS DESTRUCTION

The United States Department of Energy (DOE) is responsible for the development of systems for detecting the proliferation of weapons of mass destruction, including nuclear, chemical, and biological weapons. In both cooperative and non-cooperative environments, it is necessary to have the capability to detect the production, storage, transportation, and testing of such weapons. DOE's overall objective is to provide this capability by putting state-of-the-art technologies and tools in the hands of the treaty verification, law enforcement, and other relevant communities. **Grant applications are sought only in the following subtopics:**

a. Room Temperature Gamma Spectroscopy - Light-weight, portable gamma-ray spectrometers with high energy resolution and efficiency are needed. Therefore, grant applications are sought for the development of new detection materials and/or improved methods for growing large volume crystals used for gamma-ray spectroscopy. Proposed materials (such as wide band gap semi-conductors, gasses and scintillators) must function at room temperature or be cooled with compact electrical (i.e., Peltier) units; have superior energy resolution to that now available with conventional scintillation materials; and have a detection efficiency greater than that of presently-available room temperature semiconductors. Techniques for growing crystals must yield single crystal volumes of 5 to 10 cubic centimeters or better and have excellent characteristics for gamma-ray spectroscopy (uniformity, impurities, resistivity, charge transport). Techniques that achieve high yields of large-size spectrometer-grade crystals are preferred. Applications can include modeling efforts to better understand the thermodynamics of different crystal growth processes.

Grant applications are also sought for the development of rugged, robust gamma-ray spectrometers that take advantage of the latest advancements in material development, signal processing, new detector shapes, electrode configurationsl, and/or other innovations. Detectors must operate at room temperature, have better than 2 percent energy resolution at 662 keV, and have an efficiency that approaches that of a 1-inch by 1-inch sodium iodide scintillator.

b. Biological Agent Detection - Early detection of a biological attack, whether by direct detection of airborne biological agents or rapid detection of those who have been exposed (pre-symptomatic), is essential to minimize the impact of such attacks. Grant applications are sought for improvements in techniques that specifically capture biological pathogens and allow for signal transduction. Of particular interest are approaches that would ultimately lead to improved biological detection through higher sensitivity, specificity, or shelf-live of reagents, or via decreased dependence on reagent use or sample preparation. Proposed approaches need not be antigen-based, but may include nucleic acid recognition or other possible mechanisms. Samples could be either gaseous or aqueous base. Approaches of interest include, but are not limited to, structurally based ligand design, molecularly imprinted polymers, combinatorial receptor design or phage display. Preference will be given to approaches that have broad application to classes of pathogens and detect biological targets relevant to the Chemical and Biological National Security Program (CBNP) mission (see http://www.nn.doe.gov/cbnp), rather than those that focus loosely on surrogate compounds.

c. Advanced Research in Support of Nuclear Explosion Monitoring - The DOE National Nuclear Security Administration (NNSA) is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions, through its Nuclear Explosion Monitoring Research and Engineering (NEM R&E) program. The NEM R&E program provides research products to the Air Force Technical Applications Center, which collects and analyzes data from a network of seismic, radionuclide, hydroacoustic, and infrasound data collection stations. Within the context of one or more of these technologies, grant applications are sought to develop algorithms, hardware, and software for improved event detection, location, and identification at thresholds and confidence levels that meet U.S. requirements in a cost-effective manner. Grant applications must demonstrate how the proposed approaches would complement and be coordinated with ongoing or completed work (see http://www.nemre.nn.doe.gov/coordination) while improving capability.

***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

Program priorities focus primarily on the advancement of seismic technologies to accurately locate and identify events. Seismic identification of an underground nuclear explosion includes the ability to discriminate it from non-relevant events such as earthquakes and non-nuclear man-made events. The accuracy of both seismic location and identification methods depends on regional studies that provide high-quality ground truth information (geology, meteorological conditions, data on man-made events, etc.) and/or seismic wave propagation information that allow calibration of individual stations for travel times and/or amplitudes. High quality ground-truth data are of particular interest. Any proposed modeling effort must be strongly tied to regional data or must demonstrate applicability to a particularly distinct geophysical region.

Although priorities for the other technologies are not as high, the following areas are also of interest: (1) the development of innovative sensor designs, signal-processing techniques, or instrumentation that significantly improve signal-to-noise ratios for improved infrasound signal detection; (2) a procedure to determine the size of an infrasound event; and (3) new approaches to radionuclide instrumentation where benefits to sensitivity, reliability, or function can be achieved. Sensors must be compact, inexpensive, easily manufactured, reliable under adverse conditions, robust, simple to maintain, and have low power requirements.

d. Enrichment of Atmospheric Xenon by Selective Membrane Transfer - To detect radioactive xenon, the xenon must be enriched in air. Enrichment based on selective membranes is a preferred approach because it does not require cryogenic fluids. Xenon enrichers were proven effective even with the membranes available 20 years ago. Therefore, grant applications are sought for the development of new membrane materials, membrane packaging, and enrichment strategies to build the smallest and most efficient xenon enricher possible. Integration of new materials and/or new membrane configurations (such as spiral wound modules or hollow fiber bundles) into small, light weight systems will require test and evaluation for comparison to commercially available membranes. Therefore, it is recommended that applications include the development of a xenon membrane enrichment test system. The enrichment test system's input power must be less than 1.9 kilowatts. The output must be 2.0 liters/minute (measured at one atmosphere) at a pressure of 100 pounds per square inch gauge with xenon enrichment by at least 30 times the input level. The output gas must be dry (-40?F dew point). The enrichment test system should be smaller than 30 inches wide, 20 inches deep, and 40 inches high.

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37. SUPPORT TECHNOLOGIES FOR SENSORS USED IN NATIONAL SECURITY APPLICATIONS

The DOE Office of Defense Nuclear Nonproliferation (NN) sponsors the development of many types of sensors to help detect the proliferation of weapons of mass destruction. This topic is focused on the development of critical components that will enable or facilitate field deployment of these sensor systems. **Grant applications are sought only in the following subtopics:**

a. Small, Lightweight Power Sources for Handheld Sensors - Grant applications are sought for the development of small, lightweight power sources for handheld sensors. New, innovative and hopefully breakthrough research is encouraged; therefore, final application specific development and design may not be achievable during the life cycle of the SBIR project. However, Phase II research must demonstrate the ability to develop a power source with a power density greater than 500 Watt hours per kilogram in a package that weighs less than 3 kilograms. Proposed approaches must account for the practical limitations on safety, environmental issues (generation and disposal of hazardous waste), and cost. Typical handheld sensors used in cooperative scenarios require relatively low currents and high voltages and will be used in ambient temperatures.

b. Transportable Continuous Wave Electron Accelerators - To help facilitate field implementation and demonstration of active interrogation-based, non-destructive examination (NDE) techniques for national security applications, grant applications are sought to develop transportable continuous wave electron accelerators that operate at 3 to 4 Million Electron Volts (MeV) with user control beam power output between 0.1 and 5 kilowatts. Applicants should assume that power would be available on site. The use of cranes is acceptable for moving and transporting the system; however, it is preferred that the accelerator can be broken down into two-person portable components. Field implementation of the accelerator-based NDE system also will require that radiation exposure to surrounding personnel be minimized; therefore, applicants must maximize the use of "Cabinet Safe" designs to limit lateral (i.e., non-centerline forward) photon doses to 0.5 to 2 milliRad per hour at a defined radiological boundary within several meters of the accelerator. Flexible operation and control will be needed to accommodate many different applications; therefore, integrated monitoring and real-time user control of all major operational parameters must be incorporated in the design. All parameters must be updated in less than 0.5 seconds and be available (in both digital and analog forms) to the user. The electron transmission ratio through the electron/photon converter must be less than 10^{-6}.

c. Infrared Transmitters for Remote Chemical Sensing - The implementation of Mid Wave Infrared (MWIR) and Long Wave Infrared (LWIR) active remote chemical sensor systems require better more robust transmitter technologies. Although current CO_2 technology offers a near-term solution for laboratory and field prototype systems, technological improvements are required to move towards more spectrally diverse, portable, and easily deployed systems. Grant applications are sought for the development of:

(1) cascaded non-linear devices, such as multi-stage Optical Parametric Oscillators or Sum/Difference Frequency Generators, as LWIR light sources with high tuning rate

operation (>10 kHz) and transmit a narrow line width (approximately 1cm-1) integrated into an efficient, compact unit;

(2) new materials for LWIR non-linear optical devices, for example, patterned materials analogous to periodically poled lithium niobate but operating in the LWIR.

(3) MWIR sources or pump sources for non-linear LWIR sources based on low phonon energy host materials (such as ZnSe, CdSe, CaGa2, and KPb2Cl5) using either transition metal ions (Fe, Cr, etc.) or rare-earth ions as the optically active site with broad tunability, high repetition rate, and high average power; and

(4) thermo electrically-cooled, continuous-wave (cw) output, MWIR & LWIR Quantum Cascade Laser (QCL) devices for miniature laser transmitters with single longitudinal mode operation. (A reduction in threshold current - by improved thermal engineering, materials processing, etc. - is a typical approach to allow cw operation near room temperature. Single-facet output power greater than 10 milliWatts is required.)

d. Infrared Detection for Remote Chemical Sensing - Remote chemical sensing using passive and active Mid Wave Infrared (MWIR) and Long Wave Infrared (LWIR) absorption techniques has been progressing toward the use of larger format detector arrays, increased on-chip processing, and high-performance thermo-electrically cooled detectors. Therefore, grant applications are sought for the development of:

(1) long, pseudo-linear detector arrays (on the order of 1024 x 32) for use with imaging, dispersive spectrometers. (With many applications requiring high spectral resolution and large spectral coverage, a large number of pixels is required. A single, large-format array would allow significant spectral coverage for sensitive detection across the LWIR and even into the MWIR. In addition to increased spatial resolution, the large format array allows for the application of a dispersive spectrometer for filtering.)

(2) imaging, heterodyne detection arrays that demonstrate on-chip processing to enable large format, two dimensional arrays for infrared remote sensing. (The ability to move heterodyne signal processing on-chip should allow for increased capabilities and application. The sensitivity of a heterodyne receiver would make large field-of-view laser imaging possible, with additional capabilities offered by the added frequency and phase measurement in the heterodyne signal processing.)

(3) superior thermo-electrically cooled (TEC) LWIR detectors. (High temperature infrared detectors typically generate large direct-current photocurrents; therefore, novel solutions are sought that will mitigate this negative characteristic. In Phase I, the applicant must demonstrate the development of a high performance TEC (20? to -40?C) LWIR (8-12 micron) single-element detector with a moderate to high frequency response. Phase II must include the development of a small format array (less than 10 x 10) with reduced frequency response for potential use in integrated detector/QCL (Quantum Cascade Laser) based remote chemical sensing systems. Single element detectors must have a bandwidth greater than 10 MegaHertz and a normalized detectivity (D*) better than 10^8 cmHz$^{1/2}$/W.)

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PROGRAM AREA OVERVIEW
BIOLOGICAL AND ENVIRONMENTAL RESEARCH

http://www.er.doe.gov/production/ober/ober_top.html/

The Biological and Environmental Research (BER) program invests in peer-reviewed research at national laboratories, universities, and private institutions in order to develop the knowledge and resources needed to identify, understand, and mitigate the long-term health and environmental consequences of energy production, development, and use. The major objectives of the BER program are to contribute to a healthy citizenry, contribute to the cleanup of the environment, and understand global climate change.

To contribute to a healthy citizenry, BER supports fundamental research and technology development needed for mapping the fine structure of the human genome, which will provide the valuable information needed to identify disease genes and develop broad therapeutic and diagnostic strategies. BER projects also develop advanced imaging and other medical technologies, including highly sensitive radiotracer detectors, radiopharmaceuticals and boron compounds with affinities for tumors. In support of the nation's biomedical, pharmaceutical, and environmental activities, BER projects make use of unique facilities at the Department of Energy national laboratories to determine biological structure and how it relates to function at the molecular and cellular level.

To contribute to cleanup of the environment, BER supports fundamental research necessary for the development of advanced remediation tools for cleaning up DOE's contaminated sites, particularly in support of DOE's Office of Environmental Management.

To understand global environmental change, BER projects acquire the data and develop the understanding necessary to predict global and regional climate changes, which may be induced by increasing atmospheric concentrations of greenhouse gases.

***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

38. MEDICAL SCIENCES

The Department of Energy (DOE) Medical Sciences program covers a broad range of energy-related technologies including nuclear medicine and advanced instrumentation. DOE is interested in innovative research involving medical technologies to facilitate and advance the current state of diagnosis and treatment of human disorders.

Principles of physics, chemistry, and engineering are being employed to advance fundamental concepts dealing with human health, create knowledge from the molecular to the organ systems level, and develop innovative biologics, materials, processes, implants, devices, and informatics systems for the prevention, diagnosis, and treatment of disease and for improving human health. The DOE Advanced Medical Instrumentation program seeks to capitalize on the unique physical sciences and engineering capabilities at the DOE's national laboratories to develop new technologies that will have a significant impact on human health.

With respect to nuclear medicine, current areas of research include the development of: (1) radiopharmaceuticals as radiotracers to study *in vivo* chemistry, metabolism, cell communication, and gene expression in normal and disease states, and as therapeutic agents; (2) new radionuclide imaging systems; and (3) technological advances for boron neutron capture therapy including new boron-labeled, tumor-seeking compounds and mini-accelerator-based neutron beams. **Grant applications are sought only in the following subtopics:**

a. Micro/Nano Technologies for the Rapid Assessment of Medical Drugs - Grant applications are sought that exploit recent advances in micro and nano technology and molecular biology to develop miniaturized medical instruments that can be used in both clinical and remote settings to rapidly and reproducibly measure/monitor drugs of medical interest. Grant applications that include collaborations with one or more DOE's national laboratories are highly desired. Applications must demonstrate that the proposed technology is an improvement over current clinical procedures and that the technology will have an impact on human health.

b. Radiopharmaceutical Development for Radiotracer Diagnosis and Targeted Molecular Therapy - Grant applications are sought to develop: (1) radiolabeled compounds that could have applications as radiotracers for radionuclide imaging technologies such as positron emission tomography and single photon emission computed tomography; (2) improved and simplified production of radiolabeled compounds through the use of mini-accelerator technology or automated radiochemical analysis/synthesis techniques; and (3) radiopharmaceuticals for targeted molecular therapy. Of particular interest are radiochemical, synthetic, and combinatorial molecular engineering approaches. All efforts should ultimately result in a product for nuclear medicine use.

c. Advanced Imaging Technologies - Grant applications are sought for new, sensitive, high resolution instrumentation for radionuclide imaging. The instrumentation should advance the application of radiotracer methodologies for imaging molecular biological functions including cell communication and gene expression *in vivo.* Areas of interest include the development of: (1) new detector materials and detector arrays for both positron emission and single photon emission computed tomography; (2) software for rapid image data processing and image reconstruction; and (3) methods of integrating *in vitro* and *in vivo* instrumentation technologies for real time molecular imaging of biological function and for new drug development and utilization.

d. Boron Neutron Capture Therapy (BCNT) - Grant applications are sought for: (1) development of boron-labeled compounds that have an affinity for tumor cells in vivo and are capable of delivering lethal cellular radiation after neutron irradiation, and (2) the design and development of novel and inexpensive mini-accelerators to create epithermal neutron beams suitable for BNCT.

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4. U.S. DOE Medical Applications and Biophysical Division, http://www.sc.doe.gov/production/oher/mab/mabrd.html

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39. GENOME, STRUCTURAL BIOLOGY, AND RELATED BIOTECHNOLOGIES

The Department of Energy (DOE) supports research to acquire a fundamental understanding of biological and environmental processes. This research includes the characterization of genomes and gene products from humans and other organisms; structural biology research using beamlines at synchrotron sources and other facilities; as well as studies in computational structural biology, computational genomics, and biological information systems. Knowledge gained in this research is used to exploit genomic information, determine the structure of biological macromolecules, integrate advances in computational and mathematical sciences into biology, understand protein folding mechanisms, and clarify the relationships between genes, gene product structures, and biological function. Such knowledge should enable the public and private sector to: (1) markedly improve human health care and promote worker and public safety; (2) promote application of DNA-based biotechnology to environmental applications, like bioremediation; (3) facilitate the isolation, characterization, and treatment of factors involved in human diseases and disorders; and (4) promote cleaner industrial processes using biotechnology. Close interactions with one of the DOE laboratories or projects can be beneficial in the development of a grant application. **Grant applications are sought only in the following subtopics:**

a. Genomic Analysis Technologies - Several genomic analysis resources and technologies, initially developed under basic research grants, have now matured to the point where commercialization has become a distinct possibility. Grant applications are sought to further develop one or more of the following technologies, leading to kits or services that could be offered for sale: (1) clone libraries derived from single copy vectors, such as BACs (bacterial artificial chromosomes), YACs (yeast artificial chromosomes), and fosmids; (2) economical kits of STS (sequence tag sites) primer pairs to support analyses of "gene families" across populations; (3) DNA amplification of the whole genome of a single cell, to support subsequent genome sequencing; and (4) "leveraged sequencing" in which the net costs of sequencing several related microbes is substantially less than the cost of sequencing the microbes individually.

b. DNA Mapping Methods for Chromosome Analysis - The annotation of genomes and/or chromosomes with sequence based markers is useful for clarifying the chromosomal constituents of a species, intrachromosomal structure analysis, and quality control of the algorithmic assembly processes of DNA sequencing. DNA optical mapping and DNA FISH (fluorescence *in situ* hybridization) technologies support such annotation at kilobase to megabase resolutions, while retaining long range DNA continuity information. Grant applications are sought to further develop these technologies, leading to mapping services for them and their eventual transfer to interested customers. In addition, applications for novel technologies (in addition to DNA optical mapping and DNA fibre FISH) that would achieve the same objectives will also be considered. Constituents of interest include biochemical, instrumentation, and computational analyses.

c. Resource Management - Genome scale analytical processes are now generated resource populations with numbers in the tens of thousands, such as DNA clones, cDNAs, proteins, etc. In contrast storage systems are typically using trays holding less than a few hundred samples. Grant applications are sought for systems to store, retrieve and otherwise economically process sample numbers in and above the 10,000s range.

d. Informatics Support of Functional Analysis - The draft human genome is currently maturing into a highly finished sequence. An increasing number of genomes of model organisms and microbes are also being displayed as DNA sequence of chromosomes. Computational support for the functional analysis of these immense information resources is of increasing importance. Grant applications are sought to further develop software and computation tools for the processing and analyzing of genome scale information resources and large sub-families thereof. Grant applications must demonstrate that the tools will lead to services that will aid users who are non-specialists in computer sciences and that the services will be complementary to, rather than directly competitive with, public and private sector services already well established.

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***Please note:* (1) The technical topics are to be interpreted literally, and all grant applications must respond to a particular topic and subtopic. (2) Last year only 1 out of 4 grant applicaitons were awarded; only those applications with high scientific/teachnical quality will be competitive.**

2. Argos, P., "Sensitive Methods for Determining the Relatedness of Proteins with Limited Sequence Homology," Current Opinion in Biotechnology, 5(4):361-371, August 1994. (ISSN: 0958-1669)

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13. Uberbacher, E., "ORNL Announces GenQuest and X-GRAIL," Human Genome News, 5(5):8-9, January 1994. (Available from Human Genome Management Information System, Oak Ridge National Laboratory. Telephone: 423-576-6669) (Also available on the Web at: http://www.ornl.gov/TechResources/Human_Genome/publicat/hgn/v5n5/08ornl.html)

World Wide Web Information

1. BAC (Bacterial Artificial Chromosomes) related sites:
   a. End Sequencing
      (1) University of Washington Department of Molecular Biotechnology
      http://www.mbt.washington.edu/
      (2) The Institute for Genomic Research
      http://www.tigr.org/
   b. History-Sequence Tag Connectors Production on Human BACs
      http://www.ornl.gov/meetings/bacpac/index.html
   c. National Center for Biotechnology Information
      http://www.ncbi.nlm.nih.gov/
   d. Production
      (1) Caltech Genome Research Laboratory
      http://informa.bio.caltech.edu/idx_www_tree.html
      (2) BACPAC Resource Center at Children's Hospital Oakland, CA Research Institute

http://www.chori.org/bacpac/

e. Protein Data Bank of the Research Collaboratory for Structural Bioinformatics
http://www.rcsb.org/pdb/

f. U.S. DOE Office of Biological and Environmental Research
http://www.er.doe.gov/production/ober/ober_top.html

2. Fibre FISH (Fluorescence *in situ* Hybridization)
http://www-hgc.lbl.gov/instr/weier.html

3. Human Genome Project Information
http://www.ornl.gov/hgmis/

4. Nucleic Acid Database Project of Rutgers University
http://ndbserver.rutgers.edu/NDB/ndb.html

5. Optical Mapping
http://schwartzlab.biotech.wisc.edu/omm/omm.html

40. ATMOSPHERIC MEASUREMENT TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere and is linked with environmental degradation and human health problems. The radiative transfer properties of the atmosphere may be changing as well. Various technological developments are needed for high accuracy and/or long term monitoring of these changes to support a strategy of sustainable and pollution-free energy development for the future.

Grant applications must propose Phase I bench tests of critical technologies. Critical technologies are those components, materials, equipment, or processes that significantly limit current capabilities in one of the specific subtopics that follow. For example, grant applications proposing only computer modeling without physical testing will be considered non-responsive. Grant applications should also describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities in the technical approach or work plan. Applications submitted to any of the subtopics should support claims of commercial potential for proposed technologies, (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). **Grant applications are sought only in the following subtopics:**

a. Trace Gas Measurements Aboard Aircraft - Studies of the sources and fates of nitrogen compounds and oxidants in the troposphere require the development of innovative instrumentation. Grant applications are sought to develop instruments to measure concentrations of ammonia (NH_3) and nitric acid vapor (HNO_3) in the lower few kilometers of the atmosphere. The instruments must be sufficiently small, lightweight, and low in power consumption for use aboard medium or small aircraft (e.g. CONVAIR, Gulf Stream 1, Twin Otter, Dash 7, and smaller) that are flown at these altitudes over urban and regional distances (i.e., several hundred miles). Proposed systems must be capable of providing real-time measurements (i.e., the time for both sampling and response should be less than one minute) and be sufficiently sensitive to detect concentrations as low as 0.01-0.05 parts per billion. Grant applications must include detailed descriptions of the instrumentation (including how it will connect to the atmosphere, for the purpose of sampling, without interference from intake losses or other confounding factors) and demonstrate how the proposed technique will result in improved aircraft measurement capabilities. Promising approaches for measuring nitric acid include chemical ionization mass spectroscopy (CIMS) and tunable diode laser (TDL) infrared spectroscopy. In addition, other potential candidate technologies and related sampling problems have been identified in the literature. For the measurement of ammonia, photofragmentation-laser-induced flourescence (PD-LIF) has shown the potential for 5 ppt detection with 5-minute integration times.

b. Radiometric Instrumentation - Measurements of shortwave solar radiation (0.3 to 3.0 micrometers) and thermal radiation (3 to 100 micrometers) provide necessary information about the chemical and physical state of the atmosphere and earth's surface. Current broadband solar instruments include pyranometers, pyreheliometers, and shadowband radiometers while solar spectral instruments include scanning filter photometers, shadowband radiometers, and spectroradiometers. Thermal instruments include broadband infrared radiometers (pyrgeometers), interferometers, and grating spectrometers. Grant applications are solicited to develop radiometric instrumentation or radiometer components that: (1) improve current performance of broadband shortwave radiometers (e.g., it is desirable to achieve consistent one percent accuracy by eliminating the need for domed covers and/or other sources of uncertainty such as angle of incidence, temperature, pressure, and humidity effects on detectors, optical components, and windows); (2) significantly reduce drift, poor angular response, dome and window contamination (e.g., dust and water) errors, nighttime offsets, thermal imbalance errors, leveling sensitivity or other sources of error; (3) significantly reduce the cost of ancillary equipment such as solar seekers and trackers without degrading performance; or (4) improve the current performance of pyrgeometers to measure hemispherical irradiance in the infrared (3 to 50 micrometers) region (e.g., it is desirable to avoid contamination by solar radiation and to develop improved methods of calibration). Applicants may focus on critical components and ancillary equipment for radiometers including detectors, radiation standards and calibration methods, filter systems and monochromators, and solar tracker/seekers. Applications that make only incremental improvements to existing radiometric devices will be declined.

c. A Passive Microwave Radiometer for Measurements of Low Concentrations of Atmospheric Water Vapor - Arid arctic regions are important to the global radiation budget, as they allow surface cooling by direct radiation to space. This radiative transfer between the surface, the atmosphere, and space is predominantly affected by the amount of water vapor present. Current instrumentation for measuring atmospheric water vapor uses microwave technology at 22 GHz, but this wavelength lacks the sensitivity to measure the low concentrations of water vapor in the Arctic. The energy emitted from the 183 GHz water vapor line is much stronger than that emitted from the 22 GHz line, offering a higher signal for low water vapor values. Therefore, grant applications are sought to develop a 183 GHz radiometer for continuous unattended determination of the column and/or vertical distribution of tropospheric water vapor in the Arctic. The radiometer should also be applicable to the measurement of atmospheric water vapor variation at high latitudes.

Current millimeter wave radiometers are expensive and typically not suited to harsh environments; therefore, proposed approaches should be affordable, robust, and have a reliable and accurate automated calibration capability. An absolute accuracy of 1 Kelvin is highly desirable. Also, the system should be capable of determining the pressure-broadened 183 GHz line shape intensity from near line center to approximately 16 GHz from line center with sufficient spectral resolution to adequately retrieve profile information from this spectral interval. Phase I should determine the optimum frequency ensemble for arctic climates and demonstrate the feasibility of a fieldworthy instrument design, including a calibration system, using brassboard or other prototype construction. Phase II should produce a turnkey fieldworthy instrument system as deliverable, including software that returns column integrated or water vapor profiles in engineering units.

d. Instrumentation for Characterizing Organic Substances in Aerosol Particles - Important insights into atmospheric pollution can be gained by understanding the characteristics and temporal changes of organic substances in ambient atmospheric aerosol particles with diameters less than about 2.5 micrometers. Grant applications are sought to develop instrumentation for real-time measurements that will: (1) provide accurate estimates of both mass and speciation of organic matter as a function of particle size; (2) detect the changing degree of oxygenation of the organics in aerosols, in order to evaluate the photochemical evolution of the organic aerosol; or (3) identify isotopic and molecular-level tracers of primary and secondary organic carbon, in order to help understand the origins of the fine particulate matter. The instrumentation and associated systems must account for such factors as polarity and water solubility, and must be capable of extended operation in an outdoor, field environment. Methods are needed that will provide accurate measurements of the organic aerosols with minimal artifacts (for example, semivolatile organics are known to absorb and desorb from filter media used to collect the organic aerosol samples) for both field and aircraft operations and for both organic carbon and black carbon. Examples of past approaches include determining $^{14}C/^{12}C$ isotopic ratios as a means of estimating fossil/biogenic hydrocarbon contributions to the aerosols, optical measurements of the "blackness" of the sample as a means of determining black carbon (soot) contributions, and thermal evolution techniques.

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* Available from National Technology Information Service. See Section 7.1.

41. CARBON CYCLE MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

Eighty-five percent of our nation's energy results from the burning of fossil fuels from vast reservoirs of coal, oil, and natural gas. These processes add carbon to the atmosphere, principally in the form of carbon dioxide (CO_2). It is important to understand the fate of this excess CO_2 in the global carbon cycle in order to assess the terrestrial ecosystem response, the sensitivity of climate, and the potential for sequestration in natural carbon sinks of lands and oceans. Therefore, improved measurement approaches are needed to quantify carbon changes in components of the global carbon cycle, particularly the terrestrial biosphere, in order to improve understanding and assess the potential for future carbon sequestration.

A DOE working paper on carbon sequestration science and technology describes research needs and technology requirements for sequestering carbon by ocean and terrestrial systems [see Reference 2]. This document calls for substantially improved technology for measuring carbon transformation of the atmosphere and biosphere. The document also describes advanced sensor technology and measurement approaches that are needed for detecting changes of carbon quantities of terrestrial (including biotic, microbial, and soil components) and oceanic systems, and for evaluating relationships between these carbon cycle components and the atmosphere.

Grant applications submitted to this topic should demonstrate performance characteristics of proposed measurement systems, and show a capability for deployment at field scales ranging from experimental plot size (meters to hectares of land -- with comparable dimensions for marine systems) to nominal dimensions of ecosystems (hectares to square kilometers). Research to develop miniaturized sensors to determine atmospheric CO_2 concentration is also encouraged. In addition, Phase I projects must perform feasibility and/or field tests of proposed measurement systems to assure high degree of reliability and robustness. Combinations of remote and *in situ* approaches will be considered, although priority will be given to ideas/approaches for verifying biosphere carbon changes and for estimating carbon sequestration.

Lastly, applicants should consider collaborating with one of the two DOE centers for carbon sequestration research, which include both laboratory and university participation. One Center is investigating carbon sequestration by terrestrial ecosystems, and the other focuses on carbon sequestration by oceans. Applicants with an interest in such collaboration should contact one of the directors listed below:

?? The DOE Center for Research on Carbon Sequestration in Terrestrial Ecosystems (CSITE) is led by a consortium based at Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), and Argonne National Laboratory (ANL). The co-directors are Gary Jacobs (ORNL/e-mail: jacobsgk @ornl.gov) and Blaine Metting (PNNL/e-mail: fb_metting@pnl.gov). Other collaborators include scientists from Texas A&M University, Colorado State University, the University of Washington, North Carolina State University, the Rodale Institute in Pennsylvania, and the Joanneum Research Institute in Austria.

?? The DOE Center for Research on Ocean Carbon Sequestration (DOCS) is led by Lawrence Livermore National Laboratory (LLNL) and Lawrence Berkeley National Laboratory (LBNL). The co-directors are Ken Caldeira (LLNL/e-mail: kenc@llnl.gov) and Jim Bishop (LBNL/e-mail: jkbishop@lbl.gov). Other collaborates include scientists from MIT, Rutgers, Scripps, Moss Landing Marine Labs, and the Pacific International Center for High Technology Research.

Grant applications are sought only in the following subtopics:

a. Sensors and Techniques for Measuring Terrestrial Carbon Sinks and Sources - Measurement technology is required to quantify carbon sequestration by natural vegetation and ecosystems (i.e., carbon sinks) as well as CO_2 emissions to the atmosphere from natural or industrial sources. Grant applications are sought to develop remote, ground-based sensors and unique measurement techniques (and associated system technology, if appropriate) to detect and quantify annual net carbon changes of terrestrial vegetation for large areas, or to measure and verify the magnitude of CO_2 emissions from various sources. For the measurement of CO_2 sinks, the sensor systems or new technology must be applicable for forests, grasslands, shrub lands, agricultural lands, and/or wetlands, and have the capability of producing spatially resolved aggregate estimates of terrestrial carbon changes to an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty. For measuring emissions, the apparatus must be located at a point remote from the actual site of CO_2 release and provide accuracy estimates for CO_2 concentrations of approximately 0.5 ppm or less. Grant applications are also sought to design and demonstrate a new CO_2 analyzer with the following characteristics: (1) ability to determine the mole fraction of CO_2 in dry ambient air to a relative precision of 1 part in 3000 or better in one minute or less; (2) low gas use (30 cc/min or less) to minimize problems due to water vapor and to minimize consumption of reference gases, if employed; (3) robust enough for unattended field deployment for periods of half a year or longer; (4) cost less than $5000 when manufactured in quantity; and (5) not sensitive to motion.

Mechanical sensors must be durable in the full range of normal environmental conditions and exposures, including exposure to dust, rain, snow, heat, extreme cold, and fog. Operation in unattended, remote locations for weeks at a time, without degradation of the measurement, is also required; however, daily telecommunication with the system for monitoring performance and detecting potential operational problems would be desirable.

Proposed approaches, including both mechanical sensors and non-mechanical technology should consist of new, innovative methodologies that are significant advances over conventional scientific approaches used to measure CO_2, carbon, and related compounds. Specifically, the measurement systems should be different from, or substantially augment, existing methods for eddy flux (covariance), routine monitoring of atmospheric CO_2 concentrations, or estimating carbon quantities of land and/or ocean constituents of the carbon cycle. Grant applications proposing *in situ* or in-stream measurement of flue gas emissions will be declined, as will applications that offer only incremental or marginal improvements over existing measurement systems.

b. Novel Measurements of Organic Substances and Carbon Isotopes in Terrestrial and Atmospheric Media - Improved measurement technology is needed to better characterize processes involving carbon transformations of soil, vegetation, and associated ecosystem components and exchanges with the atmosphere. This includes both carbon content and isotopic measurements of organic matter in soils and other solid substrates, as well as the carbon content of biological tissues in various components (e.g., phytomass, detritus) of terrestrial ecosystems.

Grant applications are sought for measurements of carbon content in the atmosphere, vegetation, soil, and associated environmental media. For measurements involving the carbon content of biota and soil, grant applications must demonstrate that these measurements can be used to predict changes in carbon quantities and/or fluxes involving major components of ecosystems, with an accuracy on the order of 10 grams per square meter or less. Quantification of spatially resolved aggregate estimates of terrestrial carbon changes should have an accuracy of 10 to 25 $g/m^2/yr$ (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.

For measurements of atmospheric CO_2, development of lightweight (approximately 100 gram) sensors capable of measuring fluctuations of CO_2 in air of the order of plus or minus 1 ppm in a background of 370 ppm is solicited. The devices must be suitable for launch on ballonsondes or similar such platforms, and therefore must be insensitive to large changes in ambient temperature and pressure. They must be able to operate on low power (e.g., 9v battery), and have a response time of less than 30 seconds.

Grant applications are also sought for unique, rapid, and cost-effective methods for measuring the natural carbon isotopic composition of plant, soil, and atmospheric materials. The idea is to use isotope technology to identify sources and sinks of carbon materials, and to use carbon isotopes to distinguish relative carbon exchanges between terrestrial or aquatic media and the atmosphere. New isotope approaches and technology should demonstrate a quantitative capability for both estimating and distinguishing carbon flux among atmosphere, biosphere, and soil components of natural and manipulated carbon cycles.

Proposed new measurements of terrestrial biota and soil must be accomplished by *in situ* and/or non-invasive means and/or

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remote sensing of organic carbon forms across a range of temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system properties being observed. Instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment. The term "remote sensing" means that the observation method is physically separated from the object of interest. Research that develops unique surface-based observations and uses them for calibration/interpretation of other remotely derived data is of interest; however, except for potential application of CO_2 sensor via ballonsonde, other methods of remote sensing data acquisition by airborne or satellite platforms will not be considered.

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42. BIOLOGICAL CARBON SEQUESTRATION RESEARCH AND TECHNOLOGY

The burning of fossil fuels adds carbon to the atmosphere, principally in the form of carbon dioxide, and the potential environmental impacts have made carbon management an international concern. There is increasing national and international interest in finding natural mechanisms to mitigate the current atmospheric rise in CO_2 levels, and the Department of Energy (DOE) is focusing increasing attention on novel approaches for carbon sequestration and/or lower carbon fuel production.

The DOE is supporting research on comprehensive carbon management strategies, which could slow the current rate of increase of greenhouse gases in the atmosphere. A DOE report on carbon sequestration science and technology [see reference 2] describes research needs and technology requirements for sequestering carbon by ocean and terrestrial systems, including a discussion of advanced biological processes and chemical approaches. This topic is concerned with biological processes that slow atmospheric CO_2 increase, convert carbon into relatively stable organic or inorganic forms, and utilize biosystems to achieve the simultaneous production of fuel while sequestering carbon. Research is needed to identify and quantify mechanisms for CO_2 transformation at rates that will lead to the long term fixation or sequestration of large quantities of carbon (i.e., 10,000 to 100,000 tonnes or more of carbon per year) when applied to either natural (e.g., unmanaged terrestrial ecosystems) and managed biosystems.

Grant applications must provide for a systematic evaluation of proposed biological mechanisms and carbon sequestration systems. Estimates of the amount of CO_2 transformed also must be provided, and any assumptions concerning quantities and conditions for carbon fixation and sequestration must be clearly defined. Feasibility tests (analytical, bench, or field) performed in Phase I must demonstrate that scaling up the proposed approach can theoretically result in a significant rate reduction in atmospheric CO_2 concentration. Phase I should provide preliminary data on prospective rates and quantities of enhanced carbon transformation and sequestration with more comprehensive and peer-reviewed data sets developed in Phase II. Grant applications proposing only computer modeling without improvements in physical mechanisms or field approaches will not be considered. Also, the generation of value-added by-products (e.g., food, fiber, energy) as a result of sequestration research is highly desirable.

Applicants should consider collaborating with the DOE Center for Research on Carbon Sequestration in Terrestrial Ecosystems (CSITE), led by a consortium based at Oak Ridge National Laboratory (ORNL), Pacific Northwest National Laboratory (PNNL), and Argonne National Laboratory (ANL). The co-directors are Gary Jacobs (ORNL/e-mail: jacobsgk@ornl.gov) and Blaine Metting (PNNL/e-mail: fb_metting@pnl.gov). Other collaborators include scientists from Texas A&M University, Colorado State University, the University of Washington, North Carolina State University, and the Joanneum Research Institute in Austria. Coordination with carbon sequestration research at the National Energy Technology Laboratory (NETL) is also encouraged. **Grant applications are sought only in the following subtopics:**

a. Microbial Fixation and Transformation of Carbon - Various terrestrial and oceanic microbial populations fix CO_2 and transform the resulting photosynthetic products into residual organic compounds. Biogeochemical pathways have been identified in microorganisms that: fix carbon dioxide and produce methane that can be captured as an energy source; fix carbon monoxide and produce hydrogen (also an energy source); and fix either carbon monoxide or carbon dioxide to produce various molecules with potential biotechnological or industrial uses. Grant applications are sought to:

(1) identify and characterize biosystems capable of fixing or otherwise usefully transforming large quantities of carbon and concurrently producing high-value by-products; and

(2) develop technology to modify existing biosystems, either by conventional strain selection techniques or by genetic engineering, to enhance carbon transformation and the generation of energy (e.g., hydrogen) and/or other products (e.g., food, fiber).

For either items (1) or (2) to be considered as part of a managed carbon sequestration system, grant applications also must demonstrate that the yield of CO_2-fixed products would be significantly enhanced. For potential deployment in terrestrial systems, an engineered biosystem approach should show a capability to increase carbon sequestration by at least 1 tonne per hectare per year. Phase I must demonstrate feasibility and efficacy of proposed sequestration mechanisms, with the large-scale system and commercial applications designed and tested in Phase II.

b. Plant and Soil Sequestration of Carbon - Terrestrial, vascular plants effectively capture CO_2 from the atmosphere and produce organic compounds which sustain productivity of the Earth's ecosystems. Some of the fixed carbon is sequestered in soils or wood products of terrestrial ecosystems, and some accumulates in soils and sediments. Woody species, for example, sequester carbon as lignocellulose, which is a stored product for the lifetime of the tree. Also, for example, above- and below-ground biomass carbon contributes to soil organic matter, which may store carbon for long periods of time. Grant applications are sought to identify and quantify the biological pathways and mechanisms leading to increased quantities of carbon sequestration by soil and biotic components of terrestrial ecosystems. Areas of particular interest include the identification or development of one or more of the following:

(1) terrestrial organisms, and/or metabolic pathways and enzymatic modifications, that enhance the removal of CO_2 from the atmosphere;

(2) genetic selections and genetic engineering approaches that result in deposition of a greater fraction of photosynthetic product into forms that more effectively sequester carbon;

(3) methods for altering functional interactions of

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ecosystems, and/or for modifying the ecological relationships among terrestrial organisms, that could potentially shift the carbon balance of ecosystems in the direction of greater carbon sequestration and increased storage of "natural" long-lived organic compounds;

(4) methods for accelerating transformations of labile vegetable matter into soil organic matter fractions resistant to oxidation back to CO_2, and

(5) innovative technologies and methods to increase carbon content of soils through enhanced production and retention of residual forms of organic matter.

Proposed research should provide information about rates and quantities of carbon sequestration by terrestrial biotic and soil systems. The resulting technologies and approaches should exhibit a capability to increase carbon sequestration by at least 1 tonne per hectare per year. Phase I must demonstrate feasibility and efficacy of proposed sequestration mechanisms, with the large-scale system and commercial applications designed and tested in Phase II.

c. Fuel Production Linked to Carbon Sequestration - Grant applications are sought to develop biosystems for the simultaneous production of fuel (including hydrogen and methane) and sequestered carbon, such as humic compounds. Research questions to be investigated include:

(1) Is the physiology/metabolism of hydrogen producing *and* carbon sequestering organisms compatible, and can their functions produce different end-products when cultured together?

(2) What forms of microbial modification (e.g., genetics and culture) might conceivably enhance the simultaneous production of hydrogen and the formation of non-labile (sequestered) carbon compounds?

(3) How might linked microbial processes be optimized to produce both hydrogen and useful carbon products?

Grant applications must demonstrate that the linked carbon sequestration and fuel production system will produce meaningful yields of both CO_2-fixed products and fuels. For example, deployment of a biosystem within a terrestrial systems should increase carbon sequestration by approximately 0.5 tonne per hectare per year, while simultaneously providing net energy products for emerging markets. Phase I must demonstrate feasibility and efficacy of combined sequestration and fuel production mechanisms, with larger- and field-scale demonstrations of system performance testing, and economic analysis scheduled for Phase II.

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43. ENVIRONMENTAL MONITORING TECHNOLOGIES FOR SOILS, SUBSURFACE SEDIMENTS, AND

GROUNDWATER

The characterization and monitoring of soils, subsurface sediments and groundwater are important elements of Department of Energy (DOE) research efforts. Objectives include determining the fate and transport of wastes generated from past weapons production activities and from current energy production activities, evaluating the risks of energy-related contaminants to human health and ecosystems, and assessing and controlling processes to remediate contaminants.

Grant applications must detail why and how proposed *in situ* field technologies will substantially improve the state of the art and must include bench tests to demonstrate the technology. Projected dates for likely operational field deployment must be clearly stated. New or advanced field technologies that (1) operate in subsurface environments with mixed/multiple contaminants and (2) can be deployed in 2-3 years will receive selection priority. Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements with government laboratories or universities. Claims of commercial potential for proposed technologies must be supported by information such as endorsements from relevant industrial sectors, market analysis, or identification of commercial spin-offs. Grant applications that propose incremental improvements or enhancements to existing technologies are not of interest and will be declined, as will enhancements to predictive models. **Grant applications are sought only in the following subtopics:**

a. Real-Time, *In Situ* Measurements in Soils, Subsurface Sediments, or Groundwater - There is a need for sensitive, accurate, and real-time monitoring of geochemical and hydrogeologic processes and their interactions with biological organisms in contaminated soil, subsurface sediments, or groundwater environments (hereafter referred to as the subsurface). The use of highly sensitive monitoring devices in the subsurface (*in situ*) would allow for low-cost field deployment in remote locations and an enhanced ability to monitor processes at finer levels of resolution. Grant applications are sought to develops sensors and systems to: (1) detect hydrogeologic and biogeochemical processes that control the transport, dispersion, or transformation of contaminants (particularly metals and radionuclides) in the subsurface; (2) determine characteristics such as concentration, movement, or valence state of contaminants (particularly metals and radionuclides) in the subsurface; and/or (3) measure mass-transfer processes and rates within and among individual pores in the subsurface. Grant applications are also sought for integrated sensing and controller/signal processing systems for autonomous or unattended applications of the above measurement needs. Innovative integration of components (such as micro-machined pumps, valves, and micro-sensors) into a complete sensor package with field applications in the subsurface will be considered responsive to this subtopic.

Approaches of interest could include fiber optic, solid-state, chemical, silicon micro-machined sensors, or biosensors (devices employing biological molecules or systems in the sensing elements) that can be used in the field. Biosensing systems may incorporate, but are not limited to, whole cell biosensors (chemoluminescent or bioluminescent systems), enzyme or immunology-linked detection systems, membrane lipids, or DNA/RNA probe technology with amplification and hybridization. As substantial progress has been made in fiber optics and chemical sensing technology in the last decade, grant applications that propose minor adaptations of readily available materials/hardware, and/or can not demonstrate substantial improvements over the current state-of-the-art, are not of interest and will be declined.

b. Rapid Molecular Analysis of Microorganisms - DOE is currently funding research to investigate the use of naturally occurring communities (multiple species) of microorganisms for the *in situ* bioremediation of contaminants (particularly metals and radionuclides) in the subsurface. Metals of interest include chromium, lead and mercury; radionuclides of interest include cesium, plutonium, strontium, technetium, and uranium. It is essential to understand what microorganisms exist, the extent to which particular microorganisms tend to associate with one another within a microbial community, and whether any have a tendency to be associated with the contaminants. Grant applications are sought for the *in situ* analysis of individual microbes and microbial communities in the subsurface. Proposed approaches should: (1) characterize consortia and communities, or (2) determine the spatial arrangement, physiological status, or taxonomy of microorganisms. Although Bacteria and Archaea are of greatest interest, methods for the analysis of Eukarya will also be considered.

Possible technologies for assessing microbial community structure include: (1) DNA microarrays and DNA "chip" technologies for rapid detection of genes associated with key microbial species in natural microbial communities (such as metal-reducing bacteria or sulfate-reducing bacteria), or genes associated with metal transformation or metal resistance: and (2) flow cytometric technologies for rapid analysis and sorting of community DNA in naturally occurring microbial populations. Other *in situ* approaches for rapid analyses of microbial communities or their DNA would also be considered, provided they could be applied to the subsurface.

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c. Phytoremediation Monitoring - Phytoremediation involves the use of living plants to extract and remove metals, radionuclides, and organic contaminants from soils, subsurface sediments, or groundwater. Innovative methods are needed to monitor the performance or effectiveness of phytoremediation processes, particularly at the field scale. Performance or effectiveness monitoring is needed to determine whether cleanup levels have been met. Grant applications are sought to develop technology for monitoring the following parameters of plants used in phytoremediation: (1) the concentration and partitioning of contaminants in plant roots (sorbed or bound and internal), shoots, stems, and leaves; (2) root depth, distribution, density, and diameter: (3) mortality, health, and vigor of plants (stress indicator); (4) photosynthetic rates; (5) leaf area and evapotranspiration, and/or (6) plant tolerance or sensitivity to contaminants of interest to DOE.

Potential monitoring technologies could include: (1) spectral reflectance and thermal infrared measurement techniques, (2) laser-induced fluorescence spectroscopy and laser-induced fluorescence imaging, (3) laser-induced breakdown spectroscopy, (4) x-ray fluorescence, (5) ground-penetrating radar, (6) chlorophyll fluorescence measurements, and (7) molecular methods for monitoring soil and rhizosphere microbiology. Both remote monitoring and *in situ* monitoring approaches are of interest. Proposed technologies should significantly improve the speed, efficiency, and cost of current monitoring methods. While initial proof of principle experiments may focus on one single contaminant, the technology ultimately must be able to operate under mixed contaminant conditions such as those commonly found at DOE sites.

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PROGRAM AREA OVERVIEW - ENVIRONMENTAL MANAGEMENT

http://www.em.doe.gov

With the end of the Cold War, the Department of Energy (DOE) is focusing on understanding and eliminating the enormous environmental problems created by the Department's historical mission of nuclear weapons production. The DOE's Office of Environmental Management (EM) seeks to eliminate these threats to human health and the environment, as well as to prevent pollution from on-going activities. The goals for waste management and environmental remediation include meeting regulatory compliance agreements, reducing the cost and risk associated with waste treatment and disposal, and expediently deploying technologies to accomplish these activities. While radioactive contaminants are the prime concern, hazardous metals and organics, as defined by the Resource Conservation and Recovery Act (RCRA), are also important.

The responsibilities of DOE's Office of EM include the retrieval and processing of high level wastes, packaging and disposal of transuranic waste and mixed waste, disposition of nuclear materials, remediation of subsurface contamination, and deactivation and decommissioning of contaminated facilities. The following two topics solicit grant applications for technologies for advanced telerobotics and telepresence for EM applications and technologies for remediation and decontamination for EM applications.

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With respect to the first topic, many cleanup activities require work in environments hostile to humans. Remotely operated systems are a principal method to remove workers from hazards associated with the operations. Technologies that improve the reliability and performance of these systems are needed to enhance work safety, and innovative human-machine interfaces will improve remote work efficiency of these systems.

With respect to the second topic, new or improved technologies are sought to address issues related to repair of leaks in underground high level waste storage tanks and the monitoring of vapor and particulate fractions of process off-gases. To reduce the amount of contaminated materials to be disposed of, innovative characterization methods are needed to identify the amount of contaminated soil/debris to be excavated at a site or to differentiate between contaminated and non-contaminated concrete and metal surfaces and structures. In addition, new technologies are needed for excavation of plutonium-contaminated soils.

Background information on DOE needs can be found on the World Wide Web (http://ost.em.doe.gov/ifd/stcg/needs.htm).

44. TECHNOLOGIES FOR ADVANCED TELEROBOTICS AND TELEPRESENCE FOR ENVIRONMENTAL MANAGEMENT APPLICATIONS

The Department of Energy (DOE) Office of Environmental Management (EM) is responsible for the retrieval and processing of high level wastes, packaging and disposal of transuranic and mixed wastes, disposition of nuclear materials, remediation of subsurface contamination, and deactivation and decommissioning of contaminated facilities. Many of these activities require work activities in environments hostile to humans. Remotely operated systems are a principal method to remove workers from the hazards associated with the operations. Remote operations using various types of mobility and manipulation systems are very slow, operationally complex, and expensive. Technologies that improve the reliability and performance of such systems are needed to reduce EM project costs and to enhance worker safety. This request addresses three topical areas where it is believed that technology advancements can have major impacts on EM projects: (1) tetherless power generation, (2) advanced manipulator controls, and (3) innovative human-machine interfaces. Advancements in on-board power generation are needed to reduce, or eliminate, the need for tethers that restrict the maneuverability and range of mobile remote systems. Advanced manipulator controls capabilities are expected to increase the use of timesaving automation within the unstructured EM work environments. Innovative human-machine interfaces can improve the overall remote work effic iency of these systems. **Grant applications are sought only in the following four subtopics:**

a. Tetherless Power for Remote Systems - Self-contained power systems (in the range 30kw to 100kw) are needed for mobile remote work systems at hazardous sites. Prime mover power transmission to remote work platforms is typically done with large and cumbersome, hydraulic and/or electric cable tethers that severely restrict mobility and range. Electrochemical battery energy storage is generally insufficient to achieve reasonable operating times and requires undesirable weight additions. Hybrid electric power systems (becoming common in automotive applications) that use battery power storage and electric drives to provide load-leveling should be considered for remote system applications. Grant applications are sought to develop self-contained hybrid electric or other innovative tetherless power generation concepts. To be practical, the proposed tetherless power systems must be able to meet peak power demands and have sufficient storage capacity to support operating times on the order of a ten hour shift. In addition, modularity, size (volume and weight), and the ability to be retrofitted to existing platforms are important considerations.

b. Advanced Manipulator Controls - Advanced manipulator controls that utilize sensor-based methods are needed to control manipulator systems, including tooling, under high task uncertainties. The anticipated controls advancements would allow remote work systems to robotically perform a greater number of selected subtask operations within the complex and obstacle strewn environments typical of EM scenarios. Grant applications are sought for the development of control algorithms, software, and associated sensor systems needed for implementation on rugged field systems. Areas of interest include all forms of control (from position control through force/impedance control under contact conditions), all classes of remote manipulation systems used in EM(in terms of size, actuation, and payload), and all types of sensor modalities including vision-guided manipulation. The results must be compatible with telerobotic implementation where the systems function seamlessly between manual and autonomous control.

c. Innovative Master Controllers and Interfaces - Remote operations experience has repeatedly shown the importance of the human-machine interface to overall system performance. Within the broad area of human-machine interfaces, grant applications are sought for the development of innovative master controllers for telerobotic systems that enhance the human operator's ability to accomplish EM-type tasks effectively. Current master controllers are generally manipulator specific, cumbersome, and fatiguing to use, especially in force-reflecting mode. Proposed new master controller concepts must integrate force reflection and touch sensation, provide a minimum of six degrees-of-freedom within human-scale range of motion, accommodate multi-fingered end effectors, and provide increased human compatibility. Also, proposed systems must provide generic hardware interfaces that allow integration with a variety of manipulator systems.

d. Wearable Computer Interfaces - Recent research, taking advantage of the continual size reduction of computer hardware and displays, suggests that wearable computer technology is ready for practical application to remote operator interfaces including emerging high-fidelity, full-immersion telepresence concepts. Grant applications are sought for advanced wearable computer systems and interfaces, appropriate and useful in the human-machine interfaces of EM telerobotic systems. Proposed systems must be able to support viewing of multiple remote video sources, graphical user interfaces with cursor and select control, voice control, and wireless interfaces to other system components such as master controllers.

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http://www.robotics.ost.doe.gov)

45. Technologies for Remediation and Decontamination for Environmental Management Applications

The Office of Environmental Management (EM) is responsible for cleaning up radioactive and hazardous wastes at contaminated sites and facilities throughout the DOE nuclear weapons complex, preventing further environmental contamination, and instituting responsible environmental management. The largest contamination challenges are found at the Idaho, Oak Ridge, Hanford, Rocky Flats, and Savannah River sites. Contaminants include hazardous metals such as chromium, mercury, and lead; radioactive laboratory and processing waste, explosive and pyrophoric materials; solvents; and numerous radionuclides.

The following four subtopics identify four problem areas driven by site-specific needs. New or improved technologies are needed to address issues related to carbon-steel underground storage tanks containing high-level waste, chemical monitors for offgas constituents for high level waste treatment processes, and characterization technologies for differentiating between contaminated and non-contaminated soils/debris or concrete and metal surfaces and structures.

Grant applications are sought only in the following subtopics:

a. Repair of Leaks in Carbon-Steel Underground High Level Waste (HLW) Storage Tanks - Sixty-seven of Hanford's 149 single-shell tanks are confirmed or suspected "leakers." These cylindrical vessels, built between 1943 and 1964, have a single carbon steel liner surrounded by reinforced concrete separated by a thin layer of asphalt. The domes of these tanks are made of concrete without an inner covering of steel. Two general tank types were constructed: smaller tanks with a 20 foot diameter and 55,000 gallon capacity, and large tanks with a 75 foot diameter and varying height for capacities of 500,000 to 1,000,000 gallons. The caustic waste (pH ~12) in these tanks is classified as high-level waste, transuranic waste, and mixed waste. The current practice for retrieving the solid tank wastes is to sluice the tanks with water and pump out the dissolved or suspended solids. However, adding liquid to tanks that are known to leak or that are of questionable integrity could compound the leakage problem and release radioactive and hazardous contaminants into the vadose zone, ultimately reaching the groundwater. Grant applications are sought to develop a method to prevent or greatly retard the escape of radioactive and hazardous contaminants during waste retrieval operations from leaking tanks. Both in-tank and ex-tank solutions are interest, and proposed methods may be applied before the retrieval effort. There are multiple constraints on a potential solution: (1) tank leak(s) can only be located within an approximate 20 foot segment of the tank - therefore, the proposed method must be applied over a large general area; (2) chemicals added into the tank must be compatible with the tank contents and treatment processes to separate the HLW and non-radioactive components; (3) the method must be deployable without extensive excavation of soils around the tank; and (4) the method must be deployable in a high radiation field. This list may not be completely comprehensive, and it is expected that those knowledgeable in this field will identify additional functional requirements in the grant application and identify how their technology will address those additional requirements, as well as the constraints listed above.

b. Chemical Monitors for Offgas Constituents - Continuous monitoring as well as discrete offgas monitoring is required for the development, installation, qualification, and operation of DOE High Level Waste (HLW) HLW treatment processes. These processes (including evapor-ators, liquid effluent treatments, acid fractionators, denitration of some wastes, and glass melters for waste immobilization) have the potential of emitting RCRA hazardous volatile and semi-volatile organics and volatile or particulate heavy metals. The need for monitoring is particularly important at the Idaho National Engineering and Environmental Laboratory where HLW contains high levels of nitric acid that will add significant amounts of NO_x to the offgas. Baseline technologies for offgas monitoring rely largely on gas stream sampling. Continuous on-line or in-line monitoring of any species at the concentrations required by DPA's Maximum Achievable Control Technology (MACT) standards will require a breakthrough in instrumentation. Grant applications are invited for innovative methods to monitor both the vapor and particulate fractions of process off-gases. Analytes of interest include mercury, polychlorinated dibenzodioxins, polychlorinated dibenzofurans, heavy metals, NO_x, and possibly other small molecules in gaseous form. The ability to obtain representative samples must be developed and validated.

c. Excavation of Contaminated Soils and Debris Characterization Technology - As a result of the deterioration of storage drums, plutonium has been released to surface soils surrounding storage areas at sites within the Department of Energy complex. The soils of interest are non-homogeneous, consisting of soil, pebbles, cobbles, and small rocks. Although these soils are often compacted to depths of 6 inches, a technology that could effectively remove the top one-inch of soil would significantly contribute to the clean-up effort. Such a process would also minimize the effect of erosion, which might occur if too much soil were stripped off. One possible candidate would be a vacuuming technology that removes only the finest-grained soil material, since plutonium contamination is associated with the finer fraction soil. Grant applications are sought for vacuuming technologies and/or other technologies that can perform precision excavation of the plutonium-contaminated soils. To prevent erosion, the technology should not destroy vegetative root structures. Also, the generation of dust during soil removal, handling, processing, and containerization should be minimized. Proposed approaches could address large areas with low plutonium concentrations (e.g., 300 acres at 10 pCi/g) and/or small areas with high concentrations (e.g., 5 acres at 650 pCi/g). Although precise cleanup levels have not yet been determined, the expected clean-up level for proposed approaches must be identified in the grant application.

Grant applications are also sought for a soil/debris characterization technology or combination of technologies for the in-situ, real-time determination of radioactive contaminants, in order to reduce the volume of material to be excavated. Radionuclides of concern include U, Pu, Sr^{90}, Tc^{99}, Cs^{137}, and Co^{60}. In order to make informed, site-specific remediation decisions, the technology must be capable of providing real-time, in-situ measurements of site-specific radioactive contaminants within buried debris prior to the removal or disturbance of the debris, which may be buried up to 20 feet deep. Expected detection limits for proposed approaches must be identified in the grant application.

d. Facilities and Equipment Characterization - New or improved technologies are needed to facilitate EM's extensive efforts to cleanup contaminated and aging facilities that were constructed by DOE to support nuclear weapons production and other activities. These facilities are contaminated with radioactive materials, hazardous chemicals, asbestos, and lead (including lead paint); have exceeded their design life; and no longer serve a mission for the DOE. The potential for release of radioactive and hazardous materials to the environment and local communities and the risk of industrial safety accidents due to the deterioration of these old facilities require monitoring and maintenance. Innovative characterization methods are sought to improve the cost, efficiency, effectiveness, and the safety of deactivation and decommissioning activities. Some of the contaminants typically encountered for the needs of this subtopic include: tritium, radium, U, Pu, Co^{60}, Ni^{63}, PCBs, asbestos, Pb, and Hg.

Grant applications are sought for innovative characterization methods that differentiate between contaminated and non-contaminated concrete and metal surfaces and structures. Proposed methods should determine the type of contamination, the cross-sectional profile of volumetric contamination, and the amount of contamination present. Contaminants must be detected down to a site's free release levels. Areas for significant advances include: real-time data analysis to support decontamination and material sorting efforts; characterization of unique and complex surface geometries, including cracks, joints and crevices; characterization of vertical and horizontal surfaces (including ceilings); and identifying hotspot locations.

Grant applications are also sought for innovative characterization methods to verify the existence or absence of contamination (down to a site's free release levels) in inaccessible areas such as underground tanks and piping, ventilation ducts and wall cavities. Non-intrusive, non-destructive techniques are preferred. Opportunities also exist for remote sampling, real-time characterization and improved inspection methods for tracing and spatially locating highly contaminated piping systems. Areas for significant advances include: portable real-time characterization and analysis of standard fission products, activation products, heavy metals and other hazardous contaminants; quantitative isotopic analysis and visual inspection of piping runs, and in-situ sample collection of solids, sludge and liquids.

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